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MYCOTAXON

AN INTERNATIONAL JOURNAL DESIGNED TO EXPEDITE PUBLICATION OF RESEARCH ON TAXONOMY & NOMENCLATURE OF FUNGI & LICHENS

Volume XXVI July-September 1986

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A SYMPOSIUM ON
THE HISTORY OF NORTH AMERICAN MYCOLOGY

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The following seven contributions are part of a symposium held at the New York State Museum as the Seventh Annual Northeast Mycology Conference on April 20, 1985. It is not meant to be a comprehensive historical survey of American mycology, but to provide a forum for selected studies representing the particular interests of the participants. We had the privilege of organizing the symposium and editing the manuscripts for publication. As editors we attempted to enhance the consistency in the presentation of the information (e.g., the addition of summaries when none was provided by the authors, modifying the citation style, etc.) while not altering the content or style of the individual authors.

We would like to express our sincere appreciation to Mrs. Nancy Miller for her expert retyping of all manuscripts for publication in Mycotaxon.

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EDWARD TUCKERMAN (1817-1886)
PIONEER AMERICAN LICHENOLOGIST[1]
THE EARLY YEARS

Anna M. M. Reid

Farlow Herbarium and Reference Library
Harvard University
Cambridge, MA 02138

SUMMARY

Edward Tuckerman was the first serious student of lichens in the United States. After the publication of his first comprehensive work on lichens, "The Synopsis," in 1847 his ideas, and future articles and books dominated the field of lichenology in North America. The period from 1847 to 1886 has come to be known as the Tuckermanian Period. The present study was undertaken to provide an insight into the development of this man as a "botanist and scholar" - the inscription engraved on his tombstone.

No student of North American lichens can long escape encountering the name of Edward Tuckerman. As the first dedicated lichenist in the United States, Tuckerman described over 350 new species and varieties, many of which are still recognized today. To understand the man and the reasons for his actions, it is necessary to examine the society and the family into which Edward Tuckerman was born.

On December 7, 1817, a son, Edward, their first child was born in Boston to Edward Tuckerman, Sr., and his second wife, Sophia May. The household already included twelve year old Hannah Parkman Tuckerman, the elder Tuckerman's daughter by his first marriage.

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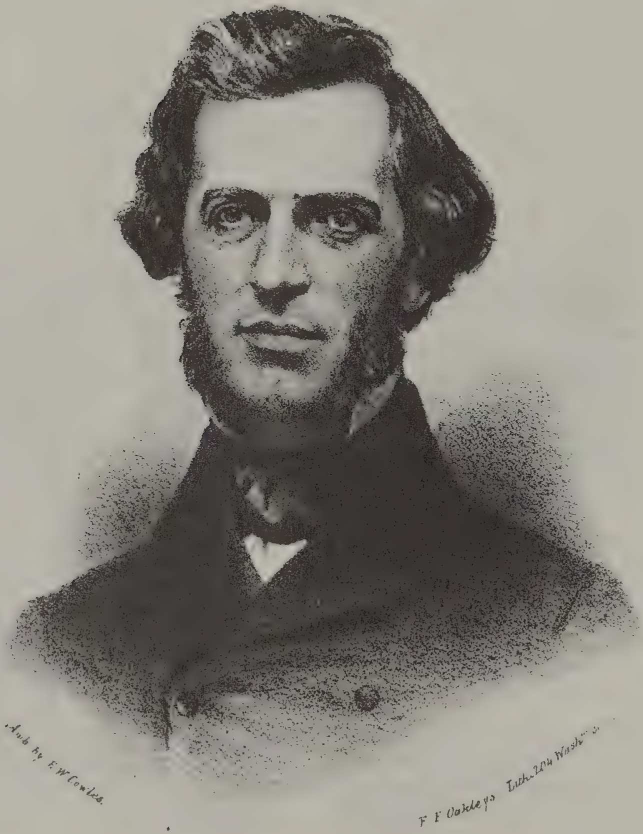
[1] This paper is based on a thesis presented in partial fulfillment of the requirements for the degree of Master of Liberal Arts, Harvard University, 1985. The research project, "The Role of the Boston-Cambridge Years in the Development of Edward Tuckerman as a Lichenologist," copyright 1985 by Anna M. M. Reid, was supervised by Professor Donald H. Pfister to whom the author wishes to express her appreciation for his encouragement and direction.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Edw. Tuckerman.

Edward Tuckerman

The infant, Edward, Jr., was closely related, on both sides of his family, to financially successful and socially prominent Boston families. On his father's side, he was a sixth generation Tuckerman in the New World.

Edward Tuckerman, Sr., had established himself in the business community as a successful merchant. At its zenith, his firm, Tuckerman, Rogers and Cushing, owned a fleet of sixty vessels. He was also active in civic, philanthropic and cultural affairs in Boston. As a young man Edward, Sr., had experienced a long period of religious soul-searching which left an indelible impression. He did not intend to permit his children to be exposed too early in life to the Unitarian beliefs then prevalent in the Boston area.

In January, 1817 Edward, Sr., married for a second time. The bride was Sophia May, herself a fifth generation American. Her father, Colonel John May, participated in the Boston Tea Party and served as an officer under de Rochambeau during the Revolution. He also made two trips to the Ohio Territory in 1788 and 1789. His business activities included ownership of May's or Union Wharf in Boston.

Edward Tuckerman, Jr., as he was known during his father's lifetime, was baptized in the Episcopalian Church on February 8, 1818. As time passed three other children were born into this religious and family-oriented household. Two sons - Samuel Parkman, who became a serious composer of sacred music and a church organist, and Frederick Goddard, whose poetry is now considered to be in the same class as Emily Dickinson's - and a daughter, Sophia May.

In 1825, Edward Tuckerman, Sr., moved his family to 33 Beacon Street, a new, four-story town house, facing the Boston Common. By this time Edward, Jr., was already enrolled in the primary school run by D.H. Ingraham on Tremont Street. After mastering the basic skills of reading, writing and arithmetic, and having reached the minimum entrance age of nine years, Edward took the examination for placement in Boston Latin School, the oldest public school in America and a first-rate college preparatory school. There was no set time period for completion of the course and the Headmaster decided when a student was ready for admission to college. Promotion was largely determined by progress in Latin, a subject in which Edward was very adept, and he completed the course of study in 1831 or 1832.

However, young Tuckerman did not attend college immediately. Instead, he continued to live at the family home and to pursue his many interests. He referred to himself as a resident graduate of Boston Latin, a term usually used to identify men who remained for extra study at a college after attaining the baccalaureate degree.

Natural history was a popular avocation at the time, and Edward was interested in minerals and shells, especially the latter. As the son of a wealthy merchant and ship-owner, he had the opportunity to purchase shells from sailors who had just returned from foreign ports and he was well known also to the itinerant shell merchants in Boston. By the time he was fourteen he had scientifically named and organized his collection with the aid of such correspondents as Charles Shepard of Yale.

Edward's other early interests included writing articles for publication usually on historical or religious subjects. Tracing his parents' family history led to a life-long interest in genealogy. Although he never published in this area, his assistance is acknowledged in volumes on the May and Williams families. Young Tuckerman's help is also mentioned by Samuel G. Drake in his "Book of the Indians and Indian Wars." Edward frequented the shops of local booksellers because of this interest in antiquarian books and the history of printing.

However, all the young man's time was not spent in Boston. He is known to have visited New York and New Haven. Worcester, Mass., the home of his father's sister, Elizabeth, was one of his favorite places and here he became acquainted with people who shared his interests.

But the issue of further formal education was sooner or later to surface. Young Tuckerman wished to matriculate at Harvard College as had many of his relatives on both sides of the family. It was the school being attended by the majority of Edward's Boston Latin classmates. Edward, Sr., had different ideas. He chose Union College in Schenectady, N.Y. The Rev. Alonzo Potter, who had been the family's minister during his five year tenure at Saint Paul's, and who also became a close personal friend of the elder Tuckerman, was back at his old post on the faculty at Union College. Edward's father undoubtedy felt that his son's first real experience away from home should not be spent at Harvard where, at that time, the Unitarian influence was strong. The elder Tuckerman's wishes prevailed and in 1834 Edward, Jr., was enrolled in the sophomore class at Union.

The young man recalled later in life that his college days were happy ones. He was active in Phi Beta Kappa and the social fraternity, Delta Phi. But, he probably felt somewhat isolated as the majority of the students were from the surrounding area.

The basic curriculum at Union was classical. There were opportunities, however, for additional studies in such areas as mathematics and modern foreign languages. Tuckerman was fluent in German in his early teens, but he may have acquired some knowledge of French at Union. The circumstances under which he became interested in botany are not known for certain. He indicated to a correspondent in 1839 that, until three years before, he had been only a dilettante student of botany. At that time, circa 1836, he began to build up a private herbarium. There is extant a petition prepared and signed by Edward and twelve of his fellow students at Union in May, 1837. Their request was for permission to take recitations in botany in place of another class. Jonathan Pearson, who in 1836 had just begun his long career at Union College, was the instructor in natural history.

Edward, Jr., completed his undergraduate studies and received the baccalaureate degree in July, 1837. At commencement, he was one of the class orators. Later that summer, Tuckerman made his first foray to the White Mountains of New Hampshire. Undoubtedly he had already acquainted himself with the published accounts by earlier botanical explorers of this area. There is recorded, in the last pages of his 1838-1839 field diary, a summary list of the flowering and non-flowering plants (excluding lichens) that he had found in the alpine area in the summer of 1837. During the following winter, Edward prepared his own guide for the determination of American lichens. He used, as a basis, all the specimens and publications available to him in Boston and Cambridge.

In the fall of 1837, Edward, Jr., matriculated at Harvard Law School. The atmosphere at Harvard had not changed, but presumably the elder Tuckerman felt that the young man, strengthened by his collegiate experience, was now better prepared for the more liberal ideas of the Cambridge institution. Edward was not seriously interested in the study of the law, but it was the philosophy of wealthy Boston families that every man should have a profession, even if he did not have a financial need to practice it. The Tuckerman children knew each was already well provided for and Edward completed the then two-year course for the LL.B. in 1839 while still having time to pursue his other interests, especially botany.

One of Tuckerman's first botanical acquaintances in Cambridge was Thaddeus William Harris, the librarian at Harvard College who also gave the lectures in natural history. Harris encouraged Edward's interest in botany and suggested possible correspondents such as Dr. Jacob Porter of Plainfield, Mass. who had a special interest in lower plants. Tuckerman also became an active member of the Boston Society of Natural History which he had first joined in 1834. Since this group now had its scientific proceedings published in the American Journal of Science and Arts, a wider audience than the local membership was assured. At the meeting of the Club on May 16, 1838, Edward displayed specimens of a fungus he identified as *Geaster quadrifidus* Persoon. This he believed was an addition to the North American flora. Many years later he remarked in a letter that this was the only fungus with which he was ever acquainted. At this same meeting he displayed large specimens of the reindeer lichen [*Cladina rangiferina* (L.) Harm.] that he had collected at the same site in Cambridge. This was his first public utterance upon lichens.

It was not easy in the 1830's for an American to have much confidence in his lichen determinations. Substrate, geographic location, color and gross morphology were the principal characters considered. Early plant collectors on this continent either sent or brought their specimens to Europe for determination as there were no suitable manuals for North America. This meant that the "type" specimens were in European herbaria.

The most important publications available on American lichens at the time were Acharius' "Lichenographis Universalis" (1810) and "Synopsis Lichenum" (1814). Muhlenberg, in his "Catalogus Plantarum Americae Septentrionalis" (1818), listed 184 species according to the Acharian System, 18 of which he reported as new. This work included no descriptions. However the sixth edition of Eaton's "Manual" (1833) provided this information. Culberson, speaking at a 1976 Symposium, considered Halsey's "Synoptical View of the Lichens growing in the vicinity of the City of New York" to be the first important publication on lichens by an American. This paper, presented to the Lyceum members in June, 1823, listed 176 species with their stations and brief descriptions. There were nine new species (diagnoses by Schweinitz) and four were illustrated in color.

Although he still considered himself a general naturalist, Tuckerman's main interest was now botany and he decided to concentrate on a neglected group - the lichens. In consideration of his intentions he gave his extensive shell collection to the Harvard Natural History Society in the spring of 1838.

In late July and early August that year, Edward and a comrade made an extensive collecting trip in New England and lower Canada. Most of the collections were made in northern Vermont and the White Mountains of New Hampshire. When the Boston Society met on August 15, Edward presented the Club with some of the recently collected specimens from these alpine regions, three of which were lichens he could not find previously reported from this country. At the time, he identified them as *Cladonia vermicularis* [*Thamnolia* sp.], *Cetraria nivalis* [probably *C. ciliaris* Ach.] and a *Parmelia.*

Since Tuckerman realized that only a limited knowledge of lichens could be obtained from books, he was grateful for the help obtained from Dr. Porter. He needed authenticated specimens and a review of his determinations by an experienced person. Edward had found out from his correspondence with Porter that Halsey now devoted himself full-time to business and no longer answered botanical correspondence. In August, 1838, Tuckerman wrote to John Torrey and sent him some of the summer's collections. The first section of Torrey's "Flora" had just been issued and Edward politely indicated he did not want to appear forward, but thought that the plants, which he could not find in the literature as having previously been collected, or if so, only once in America, would be of interest to Torrey. In addition he included the alpine lichens he could not find published in any work on American plants, but which he found to be common on the summits. He also indicated his intention to collect and work on crustose, alpine lichens the next year. Tuckerman was understandably frustrated to receive a prompt reply from Torrey on the flowering plants, but not even a comment on the lichens. Nevertheless Edward was persistent in mentioning the subject.

Tuckerman continued his botanical studies. In December, 1838 he read a paper to the Boston Society entitled, "An enumeration of the Lichens of New England not included in our Flora, with notice of some interesting species." He also read an historical account of lichenology and indicated that these papers were the commencement of a monograph on lichens. The enumeration was published in the 1839 volume of the Boston Journal of Natural History under the title, "An Enumeration of some Lichenes of New England, with Remarks." This article, plus his contributions noted in the printed Proceedings, brought Tuckerman's name to the notice of such botanists as the Rev. Moses A. Curtis, a Massachusetts native, who served in parishes in North and South Carolina. Curtis became his first correspondent located outside the northeast.

As the spring of 1839 progressed, Tuckerman also received introductions to the Rev. John Lewis Russell, also a student of lower plants, and William Oakes, a seasoned White Mountain botanist. That summer, in addition to his early trip to the White Mountains, he collected plants on Mt. Mansfield, Vt. with William Macrae and journeyed later in the season to the White Mountains with Oakes.

On his return from this last expedition Tuckerman found a letter which contained a pleasant surprise. John Torrey wanted him to elaborate the North American species of lichens for the "Flora." Abraham Halsey now had Torrey's lichen collection, but he promised to compare Tuckerman's lichens as soon as his own were returned. Edward accepted, with obvious pleasure, on the condition that he should have sufficient knowledge, when the time arrived. He suggested that he would like to visit Torrey before going to Philadelphia to study Schweinitz's collection.

In the fall of 1839 Tuckerman was again enrolled at the Law School for the optional third year, but his correspondence with men such as Oakes indicates that much of his energy was directed toward botany. He also took special courses at the Divinity School. As a resident graduate he made use of the valuable foreign herbaria and books at Harvard, and ordered personal copies of the more basic European works on lichens.

Edward reported on his winter's work on the lichens to the Boston Society in March, 1840 and the paper was published in the July issue of the Journal. It included species new to the area and additional localities for previously discovered ones. He gave full credit to other collectors such as Porter, Russell and Oakes who contributed specimens and data on collection sites. One should bear in mind that Tuckerman was by this time well trained in higher plants and continued to add to his own herbarium and to his supply of duplicates for exchange. In the 1840's he published on such difficult genera as Carex and Potamogeton and his personal study of these plants was continued throughout his lifetime.

Although Torrey generously supplied Tuckerman with authenticated specimens from various parts of the world, Tuckerman still lamented about the small number of lichens he had for comparison. When the 1840 collecting season was over, Tuckerman settled down once more at Harvard and enrolled in courses at the Divinity School. The following March he presented to the Boston Society a paper titled "Further Notices of Some New England Lichenes." This included his first descriptions of new lichen species: *Parmelia halseyana* (which he later withdrew) and *Cetraria oakesiana* Tuck. When the paper was published in the summer issue of the Journal, Edward, Jr., had already embarked on the next phase of his botanical career, his first European tour.

When first told about the possibility, young Tuckerman was not enthusiastic about the prospect of a family trip abroad with his father and mother and two sisters. Edward, Sr., had been chosen as a delegate to a Bible Society meeting in England and he decided this was a suitable time to show England and the continent to his family. As Edward, Jr., was required to accompany the group, he determined to make the best use of his free time to pursue botanical studies. Torrey's young protégé, Asa Gray, had recently published an account of his own itinerary in Europe and Tuckerman, after absorbing this article, set about obtaining letters of introduction to European botanists from Torrey and Gray, neither of whom he had yet met. He also tapped local sources such as physicians who had been trained in Europe. Edward also procured bundles of exchange specimens from local botanists, such as Oakes, for their European correspondents.

This journey, begun in April, 1841, was the most important event in Edward Tuckerman's botanical life. He had the opportunity to meet with and examine the herbaria of the most prominent English and continental botanists. He was often given authenticated specimens for his personal herbarium. There were also many opportunities for field work with resident botanists.

Although the rest of his family returned home in October, 1841, Edward, Jr., decided to remain abroad. One of his special interests on the trip was to acquire specimens collected by earlier explorers of the Americas. He had already been given an important set of lichens by Archibald Menzies who had collected them on the northwest coast of North America sixty years earlier. Tuckerman spent the winter in Berlin with an American friend. From this base he was able to make visits to other centers of German botanical activity. These contacts added to his collection of identified lichenological specimens.

After the worst of the winter weather abated, Edward, Jr., brought his letter of introduction from Greville to Elias Fries of Upsala, Sweden. There he had an opportunity to examine the lichen herbarium. Field trips and discussions with the acknowledged master of lichenology at the time enabled Tuckerman to absorb Fries' ideas on classification and species limitations. These provided the basis for his future lichenological work.

Tuckerman, after completing this loop of his journey, prepared to return to the United States. Asa Gray, newly arrived in Cambridge, located Edward on the morning of his return from Europe in September, 1842 and the pair agreed to meet early the next week to examine the higher summits of the White Mountains. Although late in the season, Gray's object was to acquire living specimens for the Harvard Botanical Garden. The friendship, thus begun, was to last until Tuckerman's death.

Now that he had returned to his native land, the question of residence was a problem for Edward. He did not even consider his parents' town house which he thought had insufficient space for his collections. He preferred to live in Cambridge, then a country town. An opportunity did present itself. The Rev. Alonzo Potter offered Tuckerman the chance to return to Union to give the lectures in botany. But the young man did not want to consider this offer as he enjoyed the atmosphere in Cambridge. Nevertheless he abided by his family's wishes and returned to his Alma Mater at the end of 1842. Instead of giving the instruction in botany he took charge of adding to the College's natural history collections. During this period Edward worked on higher plants, as well as lichens. His father's health took a turn for the worse that spring and the elder Tuckerman died May 29, 1843. This event made many changes in the young man's life, as he was now the head of the family. He remained in Boston the greater part of the summer and did not go to the mountains until late in the season. In 1843 his name appeared in the Union College Catalog as "Eduardus Tuckerman, Iun., A.M., Mus. et Herb. Curator."

By the end of 1843 Tuckerman had moved back to Boston. Dr. Harris advised him to accept the Union College post which was still negotiable, but he declined. Gray also commented that he wished Edward had some regular employment.

Tuckerman now had enough confidence in his determinations to consider preparing a set of New England lichens for distribution. He planned to start collecting the material in the summer of 1844. Now that he was back in town he was able to renew old friendships and make new ones. One thing he was pleased to see was Gray's name included in the new part of Kunth's work. He considered this a visible sign that Americans were no longer dependent on Europe, but that the relationship was a mutual one. This shift indicated that Americans were gaining in the capacity to work out for themselves their nation's botanical diversity.

In spite of his long-term membership, Tuckerman no longer attended the meetings of the Boston Society on a regular basis. Most of the members were interested in subjects other than botany. He did read one more paper on lichens to the group in November, 1844 which was published the following year. In the Proceedings of the meeting there is a table giving the numbers of genera and species common to Europe and New England. There is also a list of those lichens peculiar to the New England area. At this meeting he also reported his observations on that natural feature on Mount Washington, N.H. that was later named Tuckerman's Ravine in his honor.

That winter, among other letters, he received a note from Mrs. Sarah Alden Ripley, an aunt of Ralph Waldo Emerson. This well-educated lady, who with her husband, ran a boy's school in Waltham, Mass., was requesting Tuckerman's aid in lichen identification. She may well have been the first American woman to take a serious interest in lichens. At the end of the year, Edward found suitable lodgings in Cambridge near Harvard, his intellectual oasis.

In 1845, Tuckerman published a slim volume based on his research to date on North American lichens. The book included a list of 209 species preceded by a long essay on the general plant classification systems of Oken, Fries and Endlicher. He dedicated the volume to his friend and mentor, Thaddeus William Harris.

That spring also marked the beginning of some new plant exchanges for Tuckerman. Many of these opportunities came through Asa Gray or the Boston Society of Natural History. A good part of the next summer was spent in the field collecting specimens for his planned "exsiccati." Late in the year Edward resumed his correspondence with Rev. Curtis as he was now interested in obtaining more North Carolina lichens. He mentioned that for many years he had been preparing himself to elaborate the lichens for Torrey's "Flora" and he needed more material from the South. He concluded his letter by stating that he was once more a resident graduate and that he intended to remain one as long as he could "call himself a young man without poetry." Curtis accepted the challenge and Tuckerman's herbarium continued to grow.

In addition to his long-range projects - the "Exsiccati" and the "Synopsis" - Tuckerman was invited by Wilkes to study the lichens collected on the United States Exploring Expedition (1838-1842). The work on the government's lichens was completed before the fall, but due to bureaucratic delays the report was not published until 1862.

Tuckerman, still unhappy about his father's decision to send him to Union, was admitted as a senior to the Harvard Class of 1847. He completed the classwork, ranked sixth in the graduating class and received honors in Latin and Greek. He also finished work on the lichen section for Gray's "Manual." However, upon examining the manuscript, Gray concluded that due to the length he would not be able to include the section in the present edition of the "Manual." He did suggest that the paper should be published in the Proceedings of the American Academy. It appeared in 1847 and was reprinted as a book, with a new preface, in 1848. This publication was Tuckerman's first comprehensive paper on the lichens. It contained a few new species and there were brief diagnostic descriptions for every lichen included.

Tuckerman reasoned that his next project should be a synopsis of the southern lichens. He had completed twenty five of the books for the first double fascicule of his "Lichenes Americae Septentrionalis Exsiccati." All but four copies were sent to foreign botanists. The new taxa in the "Exsiccati" were described in his "Synopsis." The lichenist was so occupied with his projects that he no longer made exchanges, considering it sufficient to provide names for specimens submitted by the "unacquainted."

It was not long before Tuckerman was facing a problem that was to become more common as he continued to work on the southern material. What was a lichen and what was a fungus? No matter how much the "shields" resembled those of lichens, in his mind, those with "pubescent margins" (as observed with a hand-lens) were fungi.

In 1848, Tuckerman spent six weeks in the White Mountains. Upon his return he found a package from Torrey which contained some of the Fremont lichen collections. Edward was intrigued by the specimens from California and Oregon and hoped someday to have sufficient material to include them in his "Exsiccati." The fall also brought him a package of lichens from Henry W. Ravenel. With the aid of the "Synopsis" Ravenel had been attempting to study some of the lichens in his native South Carolina, but he was hampered by the lack of authenticated specimens for comparison. Edward examined the material and sent off his determinations. This was the beginning of a long and cherished relationship.

Tuckerman realized for some time that he would need to make another trip to Europe, if he wanted to study profitably the lichens of the southern states. He encouraged his southern correspondents to send more specimens as he planned to take the most difficult ones, the "cruces," to Europe with him. There were also other reasons that made the trip necessary. Edward had a long-range plan to prepare a monograph on the American species of Potamogeton. Also he planned to borrow from Wilkes the Exploring Expedition lichens so that he could compare some of the more exotic specimens, not represented in his own collection, with those in European herbaria. The last, and by no means the least as far as future study was concerned, was the purchase of a compound microscope.

He had also completed two lists of lichens for inclusion in larger works. At Sullivant's request, he prepared a list of the late Thomas Lea's Ohio lichens. He also determined the collections made on Louis Agassiz's expedition to the Lake Superior area.

Tuckerman gathered together his material and set sail in August, 1849. He landed in England and after visiting a few of his botanical acquaintances, he went to Germany where he planned to spend the winter. Few details of his itinerary survive. He did manage to see Fries as well as Montagne, a retired military physician who had done extensive work on tropical lichens. After another stop-over in England, he returned to the United States in the fall of 1850.

This trip increased his confidence with regard to the determination of species which he did not know in vivo and he planned to issue his catalog of southern lichens "immediately." But, Tuckerman's newly found confidence may have diminished with the passage of time and the arrival of additional southern collections, since the promised catalog was never published.

When Tuckerman returned to Cambridge, he purchased the Story house, the residence of his former law professor. The sale was finalized in February, 1851. This three-story, flat-roofed brick building also had a stable where Tuckerman found it convenient to store his large collection of duplicate plants. An old friend wrote jokingly suggesting that when he got a wife to put in his house she might throw away his specimens. He did find time to complete the remaining half of the first two fascicules of his "Exsiccati."

In the fall of 1851, Tuckerman was again enrolled at Harvard, this time as a senior in the Divinity School. Edward completed the prescribed course of study, including the required delivery of a sermon in a Cambridge church and he is listed among the graduates in the Class of 1852. No degrees were granted by the Divinity School at that time. Tuckerman had a life-long interest in religion and theology, but he never planned to enter the ministry.

Charles Wright, who had collected plants for Asa Gray as well as for Tuckerman, wrote to say that he had not received any letters from Tuckerman for some time and had therefore decided to give up collecting lichens. Now that he was informed that his specimens were desirable, he began to collect again. Wright, from the spring of 1851 to the summer of 1852, was associated with the United States and Mexican boundary survey. Then, and in the future, Wright was to provide many interesting specimens for the lichenist to study.

After Tuckerman returned from the mountains in the fall of 1852, he continued correspondence with Dr. William Darlington and Dr. Ezra Michener of West Chester, Pa. Michener had agreed to prepare the lichens for a revision of Darlington's flora of Chester County. He submitted his preliminary determinations and the specimens to Tuckerman. When the third edition of the "Flora Cestrica" was completed, it included a note acknowledging the lichenist's assistance, with the comment that Tuckerman should be called "The American Lichenist."

Michener had suggested to Tuckerman that perhaps it would be a good idea to combine both the northern and southern species of lichens in one book. Ravenel had already alerted some of his own southern correspondents to Edward's need for additional specimens from other areas of the south. Two who responded were John F. Beaumont and Thomas M. Peters, both residents of Alabama. Close to the end of 1852, Tuckerman again visited Philadelphia to study Schweinitz's southern lichens. He took advantage of the occasion to meet both Darlington and Michener.

In the spring of 1852 Tuckerman sent off almost all his flowering plant herbarium to Elias Fries as he had agreed to do on his last European tour. However, he did retain specimens of the genera he planned to study in the future. True to his usual custom, he was distributing to others materials he felt would be of no future use to him.

Not long afterwards, Tuckerman received a letter from Charles Wright indicating he had been chosen to be the botanist on the North Pacific Exploring Expedition. He desired information on the cryptogams so that he might know what to collect.

Parcels of lichens continued to arrive at Edward's house. A goodly number were the result of interest aroused by the "Synopsis."

As the old year 1853 ended and the new year arrived, Tuckerman had little time to devote to the lichens. The Trustees of Amherst College were seeking a new president for the school. Rev. William A. Stearns was formally chosen at a meeting of the Trustees in August, 1854. Rev. Stearns, a Harvard graduate, had been pastor of the Congregational Church in the Cambridgeport section of Cambridge for 23 years. He was well known for his interest in Harvard, education and youth. His name had been under consideration for the position for some time and Tuckerman was one of the first men he invited to join his faculty. Edward had already asked Sara Eliza Sigourney Cushing, the daughter of his father's old business partner, for her hand in marriage and the proposal was accepted. This young woman, fifteen years Edward's junior, was called Eliza and so signed herself on the marriage intentions filed on May 15, 1854 in Boston. The ceremony was performed two days later by the Rev. Stockbridge, minister of the Charles Street Baptist Church. The wedding trip to Virginia, home of the bride's late mother, permitted some time for collecting lichens. Tuckerman found one new lichen which he named *Lecidea Elizae* [*Buellia elizae* (Tuck.) Tuck.] in honor of his new wife. The description was published in 1858 and the type locality was listed as Sussex, Va. It would be some time before Edward would have the leisure to devote to lichens. The couple moved to Amherst and began a search for suitable land on which to build a house. In a letter to Asa Gray in December, 1854, Tuckerman remarked that he was busy with his history lectures, but he had prepared two new volumes (4 fasciculi) and they were ready to be filled with lichens.

Edward Tuckerman had thus started a new phase of his life. How had his personality, training and life experiences affected his lichenological thinking?

As one looks at the events in the first part of his life, it becomes clear that both the circumstances and personality of the individual, Edward Tuckerman, were important factors in his future study and writing on lichens. Although the reason he decided to concentrate on the lichens so early in life cannot be ascertained, it is likely that his youthful botanical explorations in the alpine areas of New England, where lichens are the dominant organisms, convinced him that they presented a suitable challenge. Having prepared a manuscript manual for his own use, he had a good basis for further study. By the time he was in his mid-twenties, he had received encouragement from Drs. Harris, Porter and Torrey to prepare a lichenological manual for publication. The fact that he was financially independent permitted him the leisure to develop this early interest. His major work of this period, the "Synopsis," made his name and interest known to botanists and plant collectors in many sections of North America - a largely unexplored area. Having established his reputation as "The American Lichenist," as Michener referred to him less than ten years after its publication, he worked to further the study of lichens until illness and finally death ended his dominance of the field of North American lichenology.

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CHARLES PECK AND HIS CONTRIBUTIONS TO AMERICAN MYCOLOGY*

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SUMMARY

Charles Peck, 1833-1917, was a leading American mycologist from the late 1860's until 1913. This period coincided with the professionalization of American mycology, and it was a time of intense work in descriptive taxonomy. He taught himself mycology with the help of specimens, books and such advice as he could receive by mail. Regent George W. Clinton was instrumental in creating the position that Peck held in New York State government, and together with Elliot C. Howe, he encouraged Peck's early work on fungi. Peck's influence on mycology was through his State Botanist's Reports and his voluminous correspondence.

Charles Peck helped to shape American mycology, yet he was never a student or teacher of that subject. He was self taught and passed his knowledge on through his "annual reports" and through a voluminous correspondence carried on with people interested in every aspect of mycology. He was neither the first American mycologist nor did he write a definitive book on the subject, yet he was a central figure in American mycology for most of his life and his work still manifests an influence on mycology (Murrill, 1915).

He was a man who happened to be in exactly the right place at exactly the right time in history and who was able to devote most of his productive energy to mycology for almost half a century.

By the 1860's there was a race in descriptive botany to collect, categorize and describe the fungi outside of Europe, as though it were a gigantic Easter egg hunt. The great, European trained mycologist, Schweinitz, had been gone for a quarter of a century and there was a new generation of Americans interested in

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Charles Peck, circa 1870's

mycology but none of them had the privilege of devoting full time to it. Henry Ravenel was a planter, Charles Frost a shoemaker and Charles Wright, who was trained as a teacher, led the life of an adventurer in order to travel and collect fungi. The self-appointed head of this diverse delegation was Moses Ashley Curtis, himself a church official, who studied fungi through the interpretation of Miles Joseph Berkeley in England. He collected, coordinated and filtered the specimens sent to Berkeley in order to reduce the English mycologists' workload. Curtis became a good mycologist, but he was afflicted by physical problems that made it difficult for him to do much mycology by the late 1860's. As Curtis' health deteriorated, the need for an American mycologist became acute. It was Peck who came to fill this position, and it was his talent for detailed observation and total perserverance that kept him there for nearly half a century. Curtis had duplicates of Schweinitz's fungi and had made large numbers of his own collections. These together with many others sent to him by those collectors mentioned above constituted the most important herbarium of American fungi. In the period of cursory written descriptions, authentic specimens took on a greater importance in routine identifications than they would today. A portion of these specimens was acquired by Peck. Curtis wrote to Peck on September 2, 1870, "In the course of overhauling my duplicate fungi I meet with an occasional species which I have not sent you or which may be of more use to you than to others who are getting specimens from me. I enclose a few today which will be of particular value to you as a working mycologist. When I commenced the study of these fungi, Dr. Torrey gave me all his Schweinitzian fungi, which were of great service. Even a half dozen will be of use to you."

Charles Peck was born in rural Rensselaer County about 15 miles from Albany. Although his family was not poor and was even locally prominent, his upbringing was provincial. He was eight before he made his first trip to Albany. His family who were of English extraction had resided in the town of Sand Lake since the close of the 18th century where they farmed and ran a water-powered sawmill (Burnham, 1918).

Charles attended a variety of local schools and worked (see Appendix I) for his father during the summers (Harsha, 1891). His training was in classical languages and mathematics, but while he was attending Albany Normal School, the forerunner of the State University of New York at Albany, he became interested in Botany. He recounted to his assistant, Stewart Burnham, many years later "He met a young lady at the place where he boarded who was to take a class in Botany and Natural History in a city Jewish School and was desirous of having some gentleman to go to the woods and fields to hunt flowers for class study. By accident, the lot fell on Peck who consented to go for her, and here he got his start in Botany. Upon returning home, after graduation his father put him to work in the hayfield, but at noon he would take a plant home and analyze it while the other farm hands were loafing about."

On graduation from Albany Normal, while he was still only 18, he took over a large district school for one term. This was followed by more farm work and a job as a clerk in a country store. This lasted for only a few months until he got sick and left it without regrets. After taking a college preparatory course, he entered Union College where he was finally able to study Botany along with his course of classical studies. Upon graduation with his Bachelor of Arts degree in 1859, he accepted a teaching position at the Sand Lake Collegiate Institute where he had been a student. He taught Botany, Mathematics, Greek and Latin. It was during this period, just prior to the Civil War, that he married, had his first son and continued his studies at Union until he received a Master of Arts degree. He was offered a position at Union but turned it down for what he described as "personal reasons".

In 1863 he took a new job at the Albany Classical Institute known as "Cass's Academy" and moved his family to Albany. While here he seriously undertook the study of mosses and made a most fortuitous contact, Judge Clinton (Peck, 1906).

George William Clinton was the scion of one of New York's leading families. His father was DeWitt Clinton, governor and presidential candidate. His great uncle and namesake, George Clinton, was New York's first governor and vice-president under Jefferson and Madison. This prestigious pedigree did not insure wealth or fulfillment, only a degree of prominence. George W. had an unshakeable passion for botany and had embarked on botanical studies when his father died leaving the family with limited resources. He left the serious study of botany to follow a career in law, which was to include being elected Mayor of Buffalo, becoming a district Superior Court Judge and being appointed a member of the Board of Regents of The University of the State of New York, the governing body of all public education in the State. He served in this position from 1856 to 1882 and in 1864 was appointed as a committee of one in charge of the State Museum of Natural History (Neilans, 1963). He also dealt with virtually all state matters regarding botany and was writing the botany section of the Report of the State Museum. Clinton had taken up botany again 30 years after giving it up, but this time it was as a hobby and his ambition now was to further the study of botany by encouraging young botanists in their work. He had also undertaken the study of mosses, and it was through this common interest that he met Peck. Clinton was impressed with Peck and his work on mosses, and he had him as a volunteer in the State herbarium by 1866. The nucleus of the herbarium was the collection of New York plants made by John Torrey during the second quarter of the nineteenth century, but until Peck's involvement it contained no fungi. Peck was hired part time in 1867 and full time in 1868 for $1,500/year to build the cryptogamic collections. This appointment had to be renewed each year by the legislature for the first few years. This gave Peck no small amount of anguish and several years the salary appropriation was turned down and it was only through the intercession of influential friends that it was reinstated.

The bryophytes were the first topic of Peck's study. He added to his existing specimens by collecting widely in the state. This resulted in an extensive and accurate list of New York mosses and liverworts. It also uncovered a number of new species which he sent to James, Sullivant, Austin and Lesqueroux, America's leading bryologists.

One of Peck's close friends, Elliot C. Howe, was interested in mosses but had also started to work on fungi. During the summer of 1867, when Peck was already 34 years old, they climbed a small mountain near Sand Lake and discussed the bryophyte work and Howe urged Peck to start work on a fungus list for the state. He offered his own collection of 267 species and his taxonomic outline of the fungi for a beginning. Peck allowed that it was a good idea and estimated that it would take four to five years, an estimate that he passed on to Clinton. As we now know, Peck's part in this still uncompleted task took 45 years.

Elliot Howe was a study in contrast to Peck. He was outgoing, worldly, romantic and talented in many fields, but he was never content to stay long with any one experience. He was educated as an M.D. and eventually became a prominent physician in Yonkers, New York, but he spent much of his life teaching natural history, languages and music. He even worked a short time at the New York Tribune while it was under the direction of Horace Greeley. He was a composer and songwriter and authored several compositions which achieved popularity during the Civil War. His attraction to botany brought him back to that subject several times in his life. He was credited by Peck as being the first New Yorker to take up the study of mycology wth "earnest activity" (Peck, 1899a). Howe embraced the new biological theories of Darwin and Schwendener and discussed some of them with Peck. They did not always agree.

Peck did not reveal much of his personality in his publications or in most of his letters. He was a private man. He was lean and fit, loved his home grown fruits and vegetables, and was used to physical exercise. Walking and climbing the Adirondack and Catskill Mountains was something he looked forward to. He abstained from cursing, tobacco and alcohol and was an early riser. He was a Republican and cast his first vote for John C. Fremont who ran against James Buchanan in 1856, but he would vote for the best candidate regardless of party. He once withheld payment of an election tax he felt was unjust and his field expenses were vetoed for the next two years, 1882 and 1883. He felt this was punishment to keep him in line. He was Presbyterian and had very sincere religious convictions. He believed in a simple, straightforward world governed by the Creator. His was a world where species did not change. His views against Darwin were firm and were shared by George Clinton. The work of the Tulasne brothers in France, who demonstrated the pleomorphic life cycle, was not easy for him to accept in all but the most obvious instances such as the rusts and powdery mildews.

Some of the most revealing glimpses of Peck are from Stewart H. Burnham, his assistant from 1905 to 1913. Burnham recorded incidents, conversations and reminiscences of Peck in his diaries. The diaries are in the archives of Cornell University but some excerpts are at the New York State Museum. Peck confided to Burnham that he believed that destructive natural phenomena including fungus and insect plagues could be caused by people being irreverent and desecrating the Sabbath. He thought people might laugh if they knew this, but no one who knew Peck doubted his sincerity. Even C. G. Lloyd who abused almost every other American mycologist in this Mycological Notes had high regard for Peck as a mycologist and friend (Lloyd, 1912). Peck was quoted as saying "The more we know the better it is for us." He lived by this credo and was never stingy in giving the benefit of his knowledge to others. The approximately 15,000 pieces of incoming correspondence in his files at the State Museum indicates how often he was asked for information. The letters are from school children, homeowners, government officials and scientists. There is reason to believe that they were all carefully answered. This is certainly one of the ways Peck exerted an influence on mycology.

The expansion of Peck's own knowledge was concentrated in botany and not into many other areas. This was elucidated by a small notebook he kept while at "The Worlds Columbian Commission" in Chicago in 1893, one of his few trips out of New York State. It contains only plant names recorded from the different exhibits.

Peck's first years of work with the fungi were spent in collecting, learning from the books of the Europeans Persoon and Fries and in processing the many specimens sent to him by Clinton, Howe, Gerard and others. He sent the specimens he could not identify to Curtis with the stipulation that he not send them out of the country but identify them himself. Later, he sent those he believed to be new to M. C. Cooke at Kew (Atkinson, 1918). Between 1870-1874 Peck sent a series of 400 numbered species to Cooke. It is difficult to know what Peck had in mind when he sent the specimens to Cooke, but many of them were described and given names in Peck's notebooks before they were sent. The Museum reports in which Peck's other work was published took several years to get into print. Cooke's new journal Grevillea published the species with a new epithet citing "Cooke and Peck" as the authority and did so within a matter of weeks after being received. The serial numbering of these collections was one of the few times Peck used numbers. The Cooke portions, which are presumably the holotypes, are still at Kew and are, for the most part, in good condition. Peck, however, retained large portions of each collection and these are in the New York State Herbarium (Barr et al., 1985).

After 1875 Peck no longer sent fungi out for identification and he seldom co-authored a species with someone else. He was now confident in his work and was becoming the final authority on American fungi.

Peck's work at the Museum had a predictable schedule from year to year. Most of the colder months were taken up with preparation of his annual report and in answering his voluminous correspondence. He also worked up dried specimens from his previous collections or those that were sent to him from correspondents all over the country (Bessey, 1914). This latter material was covered in a separate section of his annual report entitled "Extralimital Species". In May and June he worked in his office, but made numerous one-day trips near Albany. Sand Lake, the Helderberg Mountains and an area just northwest of Albany called Center and later known as Karner were some of his most frequented collecting areas. During July, August and September he systematically traveled to floristically interesting areas and between 1868 and 1913 he covered almost all of New York.

It is amazing to contemplate the amount of traveling he did at a time before the general advent of the automobile. He generally traveled by railroad, but stage, private wagon and a great deal of walking was required to get to some of his collecting sites. On some occasions, his wife Mary would accompany him on trips.

A review of his collecting sites reveals them to be all in New York State. Some have been totally changed through the activities of man, others have been preserved in a state very much like that when Peck knew them. One area that he loved and visited more than 25 times is the township of North Elba in Essex County in the heart of the Adirondacks. It is now well protected by being included in the Adirondack Park and contains the village of Lake Placid, the site of the 1980 Winter Olympics. Part of the township is easily accessible by car and is a major tourist area, but when Peck made his first trips there in the 1860's, it was a true wilderness area and as inaccessible as any place in New York. He made those first trips with his friend Verplank Colvin, who led land surveying teams. Colvin later became the prime proponent of forming the Adirondack Park, which became a State park in 1886 (Haines, 1978). Peck loved to climb the high peaks, most of which are in or very near North Elba. He had some narrow escapes from sudden blizzards and he undertook strenuous trips through unsurveyed regions.

Peck was he first person to climb Mount Wright while he was collecting plants in North Elba township in 1893. Twenty years previous in 1873 he, together with Colvin and two guides, had been the first on Skylight Peak. Colvin described the ascent. "August 28th. I had devoted to the climbing of Mount Skylight, which had never been ascended, even by the hunters or guides, though the fourth mountain in height in the State, as I have proved. Its slopes have been deemed almost impregnable, owing to the denseness of dwarf trees crowding like a thicket of bayonets and fishhooks upon the steep rim and top of the mountain. Without trail or mark to guide us, we set out, and climbing to the rim, fought our way through all impediments to the summit" (Carson, 1973).

Since most of the Adirondack Region has been protected from new building and development, most of the landmarks Peck cites and the houses he stayed in are still standing. North Elba is the site of Peck's major floristic work (Peck, 1899b). The locality information in this work is quite specific and it would be theoretically possible to recollect his many new species from this region in their original localities, which are relatively undisturbed since Peck's time.

Peck was not the only mycologist to work in North Elba. George Atkinson was a visitor there and in 1914 Calvin Kaufman and E. B. Mains added to the list of fungi known from the area (Kaufman, 1915).

Peck did his best work in the field. New or interesting specimens were described and sketched life size with pencil and watercolor while they were still fresh. This practice was advised by Curtis and maintained throughout his career. More than 1,300 of these drawings, most of them unpublished, remain at the New York State Museum. Like Peck's other work his drawings are accurate and have a meticulous attention to detail. In the early years he even did microscopy in the field by carrying his microscope. He dried the larger specimens in the sun or by a fire while in the field. The agarics were later remoistened by leaving them in the night air and were flattened between the fingers or in a book so they could be attached to herbarium sheets. Collections that were large enough were split into two parts, one for the sheet and the rest in a packet of newsprint. This "study material" was used for reexamination, loans and exchange. Although many of the split collections have been reunited there are still some type collections that remain in two packets in Peck's herbarium. Sometime after the turn of the century the practice of fixing fungi on sheets and of keeping "study material" was abandoned. Most of Peck's early collections were treated with a concoction of corrosive sublimate (mercuric chloride), diethyl ether, turpentine and alcohol to discourage insects and unwanted mold (Petersen, 1980). His treatment, as unwelcome as it may be to the modern worker concerned about health hazards, worked.

The herbarium, when Peck was first hired, was part of the "Cabinet of Natural History," and it was literally that. In 1872 he reported that the cabinet of the botanist was completely filled. The collections and Peck's working quarters were moved about over the years. He was moved from Geological Hall to State Hall, to the Capitol, back to Geological Hall and finally to the State Education Building in 1912. He was placed in a small upper floor room in the Capitol where the herbarium was outside in a dark corridor. The duplicates and unmounted specimens were stored in an attic where a water leak destroyed many specimens and damaged many boxes (Lloyd, 1908). It is fortunate that the herbarium was not housed in the Capitol in 1910 as there was a disasterous fire that gutted the building, destroying priceless documents and artifacts and most of the State Library.

Peck left a mycological legacy of 2,700 new taxa (Gilbertson, 1962), over 4,000 pages of publication and about 36,000 specimens. He had a sense of importance of his work early in his career. In the text of a talk prepared for a local society about 1880 he states "About 500 (species) are represented by type specimens. These must in the future give great value to the herbarium and attract to it those desiring to consult original specimens. We believe that New York State has acted wisely and well in establishing this herbarium. She is a pioneer among the states in the establishment of a public herbarium." The century since has borne out the truth of his statements.

ACKNOWLEDGMENTS

All of the personal correspondence, drawings, lecture texts, and notebooks of Charles Peck are located at the New York State Museum, as are biographical materials and the recorded personal reminiscences of Stewart Burnham. I wish to beg the forgiveness of the many correspondents of Charles Peck whose personal letters I have read. The photograph of Charles Peck is from the archives at Kew and is under British Crown Copyright. Reproduced with permission of the Controller, Her (Foreign) Majesty's stationery office, and the Trustees, Royal Botanic Gardens, Kew (c) 1986.

APPENDIX I

Chronology of C. H. Peck

1638: Ancester Henry Peck immigrated to New Haven, Connecticut from England.
1794: Eleazer Peck, great-great-grandfather moved to Sand Lake, New York.
1833, March 30: Charles Horton Peck born to Joel C. and Pamelia Horton Peck.
1847 - 1851: Attended Sand Lake Academy; worked in father's sawmill during summers.
1851 - 1852, June: Attended and graduated from Albany Normal School where he had his first class in botany; worked on his father's farm during the summers.
1852: Joined Fourth Presbyterian Church of Albany.
1852, Fall - 1853, Winter: Took over a district school of 60 students in Poestenkill.
1852, Summer: Worked in hayfields for his father.
1853, Summer: Clerked in General Store in Sand Lake for four months until he relinquished the job due to ill health.
1854: Entered Sand Lake Collegiate Institute (A boys' college preparatory boarding school known as Schram's).
1855, Fall - 1859: Attended Union College where he received botanical instruction from Professor Jonathan Pearson.
1859, June: Received B. A. degree.
1859, June - 1863, September: Filled teaching position in classics, mathematics and botany at Sand Lake Collegiate Institute.

1861, April 10: Married Mary Catherine Sliter, a former classmate from Sand Lake.
1862: Received A.M. degree from Union College and was offered a tutor's position, which he refused for "personal reasons".
1863, September - 1868, February: Filled position as instructor of Latin, Greek and bookkeeping at Albany Classical Institute known as Cass's Academy. This required moving to Albany. During this period he was earnestly working on mosses and made the acquaintance of G. W. Clinton who shared his interest in bryophytes.
1865: Peck's first paper "Catalog of Mosses" was published in the State Museum Reports.
1866: Volunteered at the herbarium of the State Museum.
1867, July 1: Started on part-time salary at the Museum as botanist in the Geological Survey headed by James Hall.
1868, May 12: Began work full-time at the Museum to build the cryptogamic collections; began work on fungi about this time and sent duplicates of his first collections to Curtis for determination.
1868, December: Purchased a new microscope.
1870: Published his first paper on fungi included in the "Twenty Second Annual Report of the Regents of The University of the State of New York on the Condition of the State Cabinet of Natural History".
1870: Second son, Charles Albert Peck, born.
1883: Officially appointed New York State Botanist by the State Legislature.
1886: Moved to 10 Lyons Avenue, Menands, New York, from 61 Dove Street, Albany, New York.
1893: Attended Worlds Columbian Exposition, Chicago.
1905: Hired Stewart H. Burnham as an assistant.
1908: Received Ph.D. (Hon.) from Union College.
1912, February: Wife Mary passes away.
1912, November: Has slight stroke, but he continues to work.
1913, February: Has major stroke which leaves him unable to resume work.
1913, March: 80th birthday celebrated by receiving testimonial letters.
1913, July 1: Homer House appointed temporary botanist.
1915, February 5: Peck's resignation approved by Board of Regents.
1917, July: Peck Testimonial exhibit of mushroom models by Henry Marchand, opened (House 1917).
1917, July 11: Charles Peck passes away.
1918: State Natural History collections moved to the new Education Bulding.
1979: State Natural History Collections moved to Cultural Education Center.

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JOB BICKNELL ELLIS 1829-1905

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Farlow Reference Library
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SUMMARY

Job Bicknell Ellis was one of the pioneers of American mycology, continuing the line of descent from L.D. de Schweinitz through M.A. Curtis and H.W. Ravenel. He worked in Newfield, N.J. in the last half of the 19th Century. His greatest interest was in the parasitic fungi of New Jersey, although his name is well known to taxonomists for the many fungi of all groups which he described from all over North America. His publications and his massive correspondence provided other North American workers with the documention of North American fungi necessary to declare mycological independence from Europe.

EARLY LIFE

J.B. Ellis (Fig. 1) was born in Potsdam, a northern New York State farming community, on 21 January 1829. His father, Freeman Ellis, was born in Harwich, Mass. and moved to Vermont with his family as a child, then to Potsdam, N.Y. His mother, Sarah Bicknell, was a member of a prominent Vermont pioneer family. Job was the tenth child in a family of fourteen (Darling, 1934; Brownson, 1965-68). Job showed unusual scholastic interest and ability; he attended the local school and worked on his father's farm until he was 16, when he undertook the post of teacher of the winter school in the nearby village of Stockholm. In 1849 he entered the classical course at Union College in Schenectady, dropping out to teach school when funds ran out, and graduated with an A.B. in 1851. (He received an A.M. at some later time, although there is no evidence he ever returned for further study.) (Raymond, 1907).

EARLY TEACHING

After graduation from Union College he spent several years as classics tutor in various academies throughout the Northeast: in Germantown, Pa. (now a suburb of Philadelphia), Albany, N.Y., and Poughkeepsie, N.Y. In February 1855 he and his sister Louisa ventured south to Charleston, S.C. and then to Alexander, Ga., with the idea of finding a teaching post and settling there. It was just before the Civil War and they were warned that the state of local feeling was such that a Northerner would not succeed in the area. They did get positions in the academy in Alexander; however,

> One morning he went to the classroom and found a huge living snake writhing about in the big open fireplace, suspended by a stout string tied tightly about its middle, and hanging from a hook in the chimney, where the boys had placed it for fun. (Anderson, 1890)

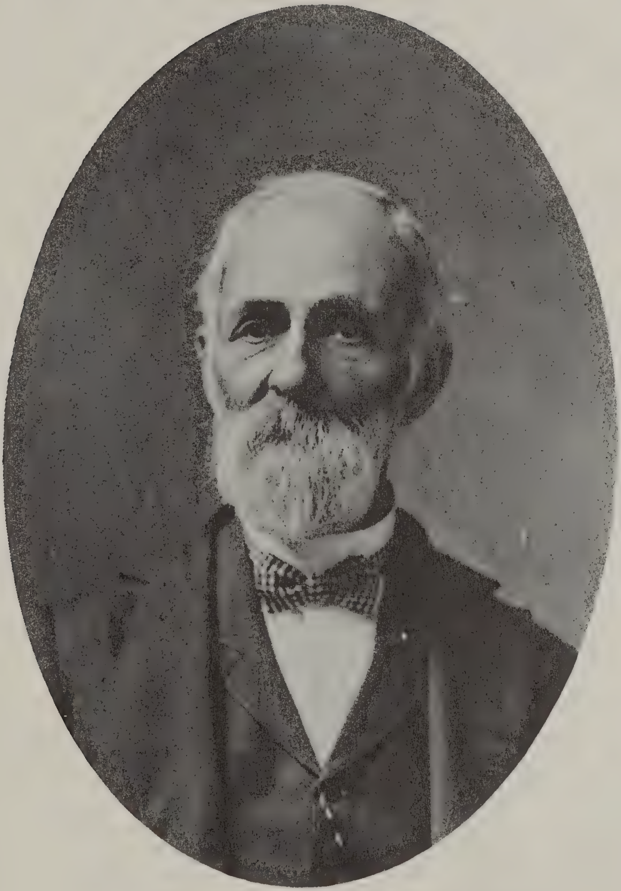
Apparently Job and Louisa did not consider it fun. They lasted only one term and returned north.

INTRODUCTION TO MYCOLOGY

During this rather unsettled period of his life Ellis was gradually drawn to botany and then mycology. He had studied a little botany at Union College, possibly under Jonathan Pearson; coincidentally, lichenologist Edward Tuckerman (A.B. 1837) and mycologist Charles H. Peck (A.B. 1859) also attended Union College in the same era (Raymond, 1907). Ellis's serious interest in botany began after college when he started collecting plants with fellow teachers on weekends. (He sold his phanerogamic herbarium of 1000 plants to St. Lawrence College, N.Y. in 1870). Then he happened to see a copy of Henry William Ravenel's *Fungi Caroliniani Exsiccati*, the first such set of dried specimens issued in North America. Ravenel was an established mycologist in Aiken, S.C. Ellis wrote to him in February 1855. Here began a correspondence that changed the direction of his life. Ravenel's biographer says,

> In Ellis, Ravenel had for the first time a student, someone to whom he could pass on his expertise in collecting, and who, in turn, would aid him with the exsiccati. In Ravenel, Ellis had a patient and interested teacher, a man who knew the plants, literature, and other scientists and who would willingly give him much guidance. Ellis's enthusiasm for mycology was as great as Ravenel's own had been when he first took up the science. Ellis sent new sets of specimens every week or two, and Ravenel kept up with him, sending identifications of each new batch of plants along with advice on collecting techniques. (Haygood, 1983).

Ravenel advised Ellis to get a copy of R.K. Greville's 5-volume *Scottish Cryptogamic Flora* (1823-1827) and Elias Fries' three books, *Systema Mycologicum* (1821-1832), *Elenchus Fungorum* (1828), and *Epicrisis Systematis Mycologici* (1836-1838). (These were the



Job Ellis

authors Curtis had recommended to Ravenel when introducing him to the study of mycology in 1846.)

Ellis's daughter Cora later wrote,

> I am almost sure these were his first two books on fungi: Fries' Elenchus Fungorum, and Fries' Epicrisis Mycologici... their bindings fastened themselves to my childish memory... and of all my father's books those are the only two copies I would care about keeping myself... I often used to watch him pore over the pages, and wondered he did not tire of it. (Farlow Herbarium Archives (FH): Cora Ellis 6 Mar., 1906)

We know he also owned the Systema. His mycological foundations were thus firmly laid in the European tradition.

Ravenel introduced Ellis to the necessity of sending undescribed species to recognized European mycologists for naming, explaining,

> It is customary among Botanists, that those who receive & name plants for beginners, describe also any new species that may occur -- this is only just & proper ... Our means in this country are too limited for that full comparison which should precede the publication of a species as new. We are compelled to obtain aid from the older European mycologists who have been making these things their study for half a century & who have large collections from all parts of the world. (New York Botanical Garden (NY) Archives: H.W. Ravenel, 14 Nov., 1855).

Ellis immediately began contributing specimens for Fungi Caroliniani Exsiccati, and continued sending specimens to Ravenel for determination. His correspondence with Ravenel continued unbroken, except for the Civil War years, until Ravenel's death in 1887.

1856-1865

In 1856 Ellis returned to Potsdam and, on 19 April married Arvilla J. Bacon (Fig. 2) -- "an event which made it possible for him to do the enormous and valuable work he has since done for American mycology" (Anderson, 1890). Vill, as he called her, was born 8 February 1821 in Potsdam, daughter of Timothy and Mary S. Bacon (Ellis, 1899). He took the position of principal of Canton Academy, near Potsdam; there their only daughter Cora was born 12 July 1857 (Darling, 1934). Cora later became "one of New York's most popular professional musicians." (Anderson, 1890)

In the spring of 1858 they packed up and journeyed to Ogdensburg, N.Y. with the idea of moving to Minnesota, but delays

Miss Arvilla Jane Bacon, about 20 years

in navigation on the Great Lakes were so great that they returned to Potsdam and eventually gave up the plan. Instead, they bought 13 acres of land in Potsdam, built a house, and began farming. He resumed teaching school; Mrs. Ellis also taught school periodically (Darling, 1934).

Meanwhile, the Civil War broke out. In September 1864 Ellis entered the Union Navy and served on the steam frigate Susquehanna of the North Atlantic Blockading Squadron. This is the most thoroughly documented period of his life; his letters to his wife and the diary he kept have survived and have been published (Ellis, 1865-1905; Darling, 1934). His accounts vividly describe life on the warship (he was sick most of the time with seasickness or bad colds) and the bombardment of Fort Fisher, N.C., December 24-25, 1864 and January 13-15, 1865, when the fort was taken. And once again he taught school! On Dec. 29 he entered in his diary, "Installed as schoolmaster today & relieved from lamplighting & other duties." His position involved "hearing the boys recite two hours each day from 1 to 3 p.m." To make the time pass bearably, he wrote poetry, studied German, and sent instructions to Mrs. Ellis on the management of the farm. He found his belief in spiritualism, to which he had been introduced by his wife, being strengthened during this time of hardship (Darling, 1934). And, even in wartime circumstances Ellis managed to do a little mycology. The Susquehanna was based at the Brooklyn Navy Yard. When he could go ashore,

> a bookseller on Broadway allowed him to sit and write in the store, copying parts from some valuable book on fungi that was for sale there -- but too expensive for him to buy. (FH Archives: Cora Ellis, 6 Mar. 1906)

Ellis's letters to his family were cheerful and positive in tone; the diary entries were more stark.

> Jan. 29: Last night was a dreadful night. The deck was continually drenched with foam spray so that the men continually wet & chilled, suffered most severely, many of them having their fingers & toes frozen. About midnight I went on deck for a few minutes. The frozen spray was continually dashing over the deck -- the black clouds above & the blacker sea below, its white crested waves lit up with a pale phosphorescent fire & gleaming in the darkness like the fabled Phlegethon, all together made up a scene of sublimity not often seen; but to me oppressed with deadly sea-sickness the sight was sickening & I hastened below to my hammock.

> Apr. 15: Pres. Lincoln died this morning. May the avenging furies pursue the murderer through this life & let his polluted soul go down, all black with infamy to the infernal shades.

> Apr. 22: I have felt degraded ever since I have been here & no amount of money & I might perhaps safely say no motive not even patriotism will ever induce me to put myself in the like position again. (Darling, 1934)

Meanwhile, he started thinking about selling the house in Potsdam, which shook alarmingly in the wind. Apr. 17: "I do not feel as if I wanted to live where we must be in fear half of our lives of having our house come tumbling down over our heads." He suggested moving to Nebraska, where some acquaintances seemed well pleased with the country. The diary and letters do not reveal what became of these ideas. Ellis was discharged from the Navy on May 18, 1865, and went home to Potsdam.

However, while on the warship he had met a man named Hale from New Jersey, who told him of the good climate in the vicinity of what was to become Newfield (Anderson, 1890). By early August Ellis had packed up his family and possessions and made his final move, to a town so new it was not even named yet. He related many years later,

> I had come down from Potsdam in June and bought the lot on the corner of Madison and Catawba Avenues..., but when my wife came in August, she was not pleased with that location and we exchanged it for the place where we have since lived, and began the battle of life anew. A house to live in was first to be had; and while I was at work on this [it took him four weeks to build it!] Mrs. E. took a hatchet and trimmed off the sprouts on the stumps around the house, where the trees had been lately cut away, leaving the best sprout on each stump; and these sprouts that she left are now the trees that spread their branches above the roof and give us a grateful shade. (Ellis, 1899)

He recorded in his diary that the total cost of the move and new house was $1167.87. Photographs of the house were later published in *Mycologia* (Seaver, 1928).

Job and Arvilla Ellis spent the rest of their lives on Northwest Boulevard in Newfield; they rarely and reluctantly ever ventured far from home thereafter. He wrote later to W.G. Farlow,

> I go very little anywhere, for as soon as I get away from home, I get out of order -- headache or something -- & that is why I stay mostly at home where I get along tolerably well. (FH Archives: J.B. Ellis, 9 May, 1893)

1865-1878: DEVELOPING MYCOLOGIST

During the next decade or so life resumed a pattern similar to that of the northern New York years. Ellis "engaged in a variety of pursuits" according to Anderson (1890): he farmed his 15 acres, tended a peach orchard, and taught school sporadically (Darling, 1934). The couple participated in some of the activities of the new town: Arvilla was elected president of the Library upon its organization in 1866, and Job was secretary of the Franklin Mutual Building and Loan Association, incorporated in 1873 (Haydock, 1891).

During this period Ellis was steadily developing his mycological knowledge, acquiring books and specimens, and increasing his correspondence with mycologists and collectors in many countries. His scientific correspondence was often in Latin, no problem for a classical scholar! Besides Latin and Greek, he was familiar with German, French, Polish, Swedish, Italian and Spanish (Anderson, 1890).

Meanwhile, he still had to send specimens to other mycologists for determination. From 1875 to 1879 he sent many specimens to M.C. Cooke in England who published them in the journal Grevillea with the designation "Cooke & Ellis." Their species concepts inevitably differed, culminating in a published exchange, acrimonious on the part of Cooke, polite and objective on the part of Ellis (Ellis, 1879; Cooke, 1879; Ellis, 1880; Cooke, 1880). The exchange was precipitated by Ellis's taking 20 species of 6 genera, including 9 Cooke & Ellis species, and reducing them to synonymy! From this time he published his own descriptions, saying to Farlow,

> I have made up my mind not to send things to Cooke in the wholesale way I have been doing but shall publish most of them myself. I may as well make mistakes now & then as for him to do it. (FH Archives: J.B. Ellis, 12 Jan., 1879)

He had already produced his own first scientific paper. "New species of fungi found at Newfield, N.J.," describing 16 new species, had been published in the Bulletin of the Torrey Botanical Club in New York in 1874. (His 202nd and last paper appeared in 1905, the year he died.) (Farlow, 1906).

Ellis studied fungi of all groups, but was most interested in the parasitic Ascomycetes, particularly the Pyrenomycetes. (In her 1952-54 work Edith Cash listed over 4000 species named by Ellis.) He followed the taxonomic concepts then current, using H.G. Winter's classification system for his book on Pyrenomycetes; the more recent division of Ascomycetes into unitunicates and bitunicates has made his taxonomy obsolete. However, many of his descriptions stand as valid species.

EXSICCATAE

In 1876 Ellis wrote for the first time to William Gilson Farlow at Harvard University in Cambridge, Mass. Farlow had studied under Asa Gray at Harvard and Anton de Bary in Europe, and was just beginning his career as Cryptogamic Botanist at Harvard. Thereafter Farlow was the source of considerable influence and support. In 1877 Ellis decided to start a set of exsiccatae called Fungi Nova-Caesareenses (Fungi of New Jersey; FNC). He distributed two copies of the first century (i.e. a volume containing 100 specimens) -- one to Farlow and one to Isaac C. Martindale of Philadelphia. (Stevenson, 1971, however, lists partial sets of FNC in 5 American herbaria.) Farlow soon persuaded him to recall FNC, broaden the scope of the series to North American Fungi (NAF), and issue the specimens in bound books instead of loose sheets in boxes. Ellis after much indecision and consultation also decided to print descriptions in English rather than Latin. Some of the collections of FNC were reissued in early centuries of NAF, which grew from 35 sets (Century 1) to 60 (Century 17). There was much discussion of publishing NAF in partnership with Farlow; it was finally decided Ellis should publish the series, and Farlow should supply and "edit" individual centuries as he had material. Farlow did in fact "edit" Centuries 3 and 11, with Ellis listed as publisher (FH Archives: Ellis, 1878).

Since Ellis could not afford the cost of the bound volumes, Farlow had 35 copies each of the first 2 centuries bound into book form. Books for the subsequent 34 centuries were made by hand by Mrs. Ellis. As the number of subscribers had increased to 60 by the time of the last volume in 1898, she had made some 2000 books and prepared and packaged some 200,000 specimens in those 20 years.

THE HAT IN THE RING

In 1878, with the beginning of NAF, Ellis

> dropped everything else and commenced to devote his whole time to fungi, desiring to disseminate more widely a knowledge of North American fungi and to arouse home botanists if possible from their apathetic indifference towards these plants. (Anderson, 1890)

He soon succeeded; demand for NAF was immediate and kept increasing through the years. The Ellises supported themselves through sales of the exsiccatae and through Mrs. Ellis's work. As he said,

> Mrs. E. did what she could to help along, she sewed hats, made vests and coats and did other work that came to hand, to keep the wolf from the door, never complaining, always cheerful and hopeful. (Ellis, 1899)

Ellis's correspondence was of mammoth proportions; he must have kept the Newfield Post Office in business single-handed. He had early established contacts with such British and European workers as M.J. Berkeley, M.C. Cooke, Heinrich Rehm, and Felix de Thuemen; and later, Heinrich Georg Winter, Paul Sydow, and P.A. Saccardo. He wrote to and exchanged specimens with collectors throughout North America. (A map of collecting locations is given in Fig. 3; it shows quite thorough coverage of the continental U.S. at least.) Some of the major correspondents were: Farlow (at Harvard); Peck (at New York State Museum, Albany); Ravenel (South Carolina); Everhart (Pennsylvania); Kellerman (Kansas, Ohio); Atkinson (at Cornell, Ithaca, N.Y.); Burt (Middlebury, Vt.);

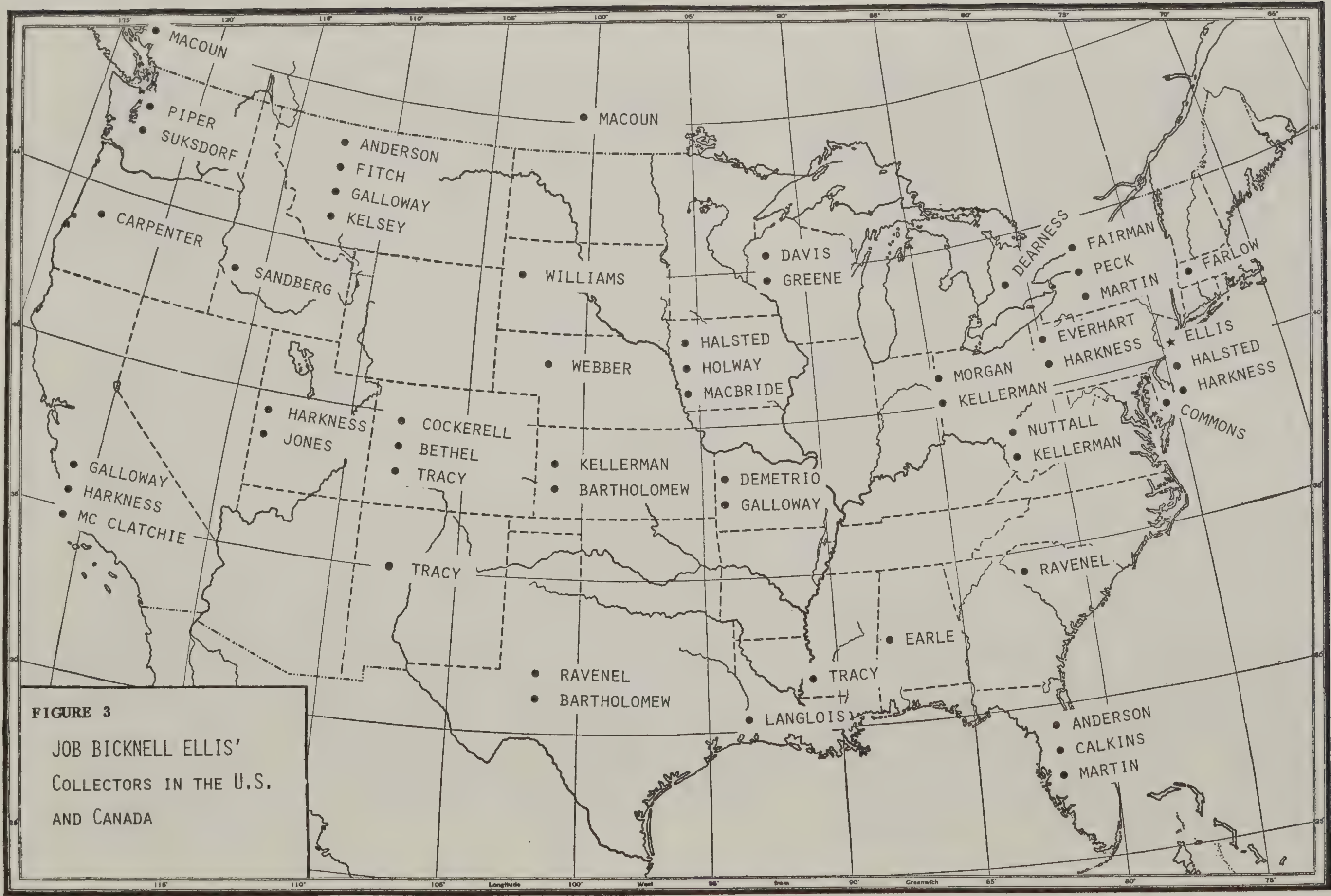

MACOUN
PIPER
SUKSDORF
CARPENTER
MACOUN
ANDERSON
FITCH
GALLOWAY
KELSEY
SANDBERG
WILLIAMS
DAVIS
GREENE
DEARNESS
FAIRMAN
PECK
MARTIN
FARLOW
EVERHART
HARKNESS
ELLIS
HALSTED
HARKNESS
COMMONS
HALSTED
HOLWAY
MACBRIDE
WEBBER
MORGAN
KELLERMAN
NUTTALL
KELLERMAN
HARKNESS
JONES
COCKERELL
BETHEL
TRACY
KELLERMAN
BARTHOLOMEW
DEMETRIO
GALLOWAY
GALLOWAY
HARKNESS
MC CLATCHIE
TRACY
RAVENEL
EARLE
TRACY
RAVENEL
BARTHOLOMEW
LANGLOIS
ANDERSON
CALKINS
MARTIN
Longitude West from Greenwich

FIGURE 3

JOB BICKNELL ELLIS'
COLLECTORS IN THE U.S.
AND CANADA

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Halsted (Iowa, later Rutgers in N.J.); Calkins (Florida); and W. C. Stevenson (Pennsylvania).

In 1880 Ellis began his famous association with Benjamin Matlack Everhart (1818-1904), a wealthy but peculiar merchant of nearby West Chester, Pa. and a knowledgeable mycologist (Harshberger, 1899). From that time the majority of new fungi carried the authorship "Ellis & Everhart," as did many papers, Centuries 16-36 of NAF, Centuries 1-14 of the later exsiccata Fungi Columbiana and the book North American Pyrenomycetes. The team was so well known that a later worker commemorated it in the genus "Elletevera" (Deighton, 1969)!

It is not clear whether Everhart actually participated equally in the mycological determinations; Ellis was always generous with credit to others, often citing collectors as co-authors. Everhart certainly provided Ellis access to his extensive mycological library, and financial support for general purposes as well as the publication of NAF and North American Pyrenomycetes. His letters to Ellis frequently ended with "Check enclosed. Please don't thank me." (NY Archives).

Being of a retiring nature, Ellis did not attend the usual scientific meetings and met few of the scientists with whom he corresponded. A longtime friend, William C. Stevenson, Jr., described one notable exception:

> In 1884 the British Association for the Advancement of Science met in Canada, and the American Association in Philadelphia. It was arranged that a joint meeting of the two associations should be held at the Academy of Natural Sciences in Philadelphia on the evening of Sept. 8. Mr. Ellis was present at that joint meeting. Here for the first time he met scores of workers in the botanical and mycological fields whom he had known by name and through correspondence. It was a great treat to him, and he often rehearsed to me the great pleasure that evening gave to him. It seemed to add new spirit and enthusiasm to his future work and plans. (Kellerman, 1906)

(Ellis had been elected a corresponding member of the Academy of Natural Sciences of Philadelphia in 1878, of the Cryptogamic Society of Scotland in 1882, and of Die Kaiserlich-Koenigliche Zoologisch-Botanische Gesellschaft of Vienna, also in 1882.) (Anderson, 1890).

PUBLICATION

In 1885 Ellis, in association with Everhart and William A. Kellerman of Kansas, founded the Journal of Mycology -- the second mycological journal in the world and the forerunner of Mycologia. Ellis furnished most of the articles for the first few years, notably the first monographs on parasitic fungi of North America. In Kellerman's opinion, the development of American mycology was greatly facilitated by the availability of this material (Kellerman, 1906).

Ellis and W.R. Gerard contributed the section on Fungi to N.L. Britton's Catalogue of Plants Found in New Jersey, which was dated 1889 but actually appeared in 1890. Then, in 1892, Ellis and Everhart published the book North American Pyrenomycetes, the first comprehensive treatment of this group for North America. (Incidentally, the illustrator of the book, Frederick W. Anderson, wrote the biography of Ellis which appeared in the Botanical Gazette in 1890 and was the basis for most of the later biographies I have seen. [Stafleu & Cowan, 1976]). He had spent a great deal of time with the Ellises while doing the illustrations, probably during the winter of 1889-1890, and had the opportunity to hear the anecdotes that make up a life story. Anderson, a botanist, editor and artist from Great Falls, Montana and later New York City, did not live to see his drawings published; he died at the age of 25 in 1891. (Kelsey, 1891).

FUNGI COLUMBIANI

Ellis and Everhart began the last exsiccata series, Fungi Columbiani ("Fungi of America") in 1893 as a "second edition of NAF." Sixty copies were offered. Centuries 1-14 (1893-1899) were published by Ellis and Everhart, 15 (1901) by C.L. Shear, and 16-51 (1901-1917) by Elam Bartholomew. The original purpose of the exsiccata was to make available a partial set of specimens identical to those in NAF, since there were not enough replicates of some of the numbers to make additional copies of NAF. Later centuries of Fungi Columbiani contained species not in NAF. Detailed accounts of Fungi Nova-Caesareenses, NAF, and Fungi Columbiani are given by Stevenson (1971). Stevenson was irked by Ellis's sometimes vague collecting data and by his frequent practice of gluing specimens to the sheets rather than enclosing them in packets, thus making them harder to study without damage (this method had been strongly advocated by M.C. Cooke).

LAST YEARS

In 1896 Ellis sold most of his herbarium to the New York Botanical Garden, then being formed. (In 1900 they bought the remainder, for a total of 80,000 specimens, according to Underwood, 1900; they also purchased much of his library.) The herbarium was considered at that time the largest private collection in North America. All groups were covered, although the large Basidiomycetes were less well represented. Included were his own specimens, those sent to him by correspondents throughout Canada and the U.S., and many exsiccatae published by European, North American, and South American workers (Harshberger, 1899, p. 267-271). The European exsiccatae contained in addition many specimens from Africa and the Far East; the collection was truly worldwide in scope.

On March 15, 1896 he wrote to Elizabeth G. Britton at the New York Botanical Garden:

> The Herb. is all packed and ready to go. A part of my life will go with it, but the thought that it is only temporarily lost to me makes the parting endurable. (NY Archives)

This last remark, a mystery at first reading, refers to the fact that the Ellises were spiritualists and "firm believers in the continuity of life and the truth of spirit return," in Ellis's words (Ellis, 1899).

In 1899 Arvilla Ellis died. In a touching tribute her husband wrote,

> During the year just passed, while she has been unable to attend to her usual duties and I have attempted to act in part as a substitute for her, I have begun to realize the vast amount of work she has done, and I see that what little success we have achieved in these later years is principally due to her assistance. (Ellis, 1899)

He talks about her preparing specimens and making those 2,000 books:

> ...in addition to the daily work of keeping the house in order. I have sometimes blamed myself for allowing her to do such an amount of work, but we were both doing all we could and both enjoyed the work, acting on the Bible precept, "Whatever thy hand findeth to do, do with thy might." (Ellis, 1899)

He wrote to Heinrich Rehm in Germany,

> The North American Fungi on account of the death of my wife will not be continued. (Rehm, 1906)

Contemporary American scientists also recognized the vital role Mrs. Ellis had played:

> It may justly be said that to her extended labor... no less than to that of Mr. Ellis are American mycological students indebted for the valuable and extended issues of exsiccati that for the past twenty years have issued from this quiet house. (Underwood, 1899)

His daughter Cora said that he himself began to fail from that time. She came back from New York for good, probably in 1902 when he deeded the property to her. But, characteristically, he kept up the correspondence and identification work for as long as he could hold a pen, and when he couldn't he dictated letters to Cora. He died peacefully at home the night of December 30, 1905, at the age of 76.

COMMENTARY

It is hard for us now, with our voluminous literature and computerized data bases, to imagine the scarcity of information that confronted Ellis when he entered the field 130 years ago. He belonged to an early era of American mycology, close on the heels of Schweinitz, Curtis, and Ravenel, and contemporary with Peck, Frost, and Morgan. He had to rely on Europeans for identifications and books at first, and built up his own American resources almost from scratch. Both amateur and professional mycologists would recognize him as one of themselves. He was an amateur in that he was largely self-taught, a professional in the pioneering scientific work he did in systematizing thousands of undescribed American species. And, as a pioneer, according to Kellerman,

> his descriptions are of course not always full, his knowledge of some things he published was scant, but who could or did do better! Pioneers can not do the critical work that is possible to the well trained student who has the advantage of all the facilities and appliances later developed. (Kellerman, 1906)

... and, one might add, the pioneering work to build on!

Kellerman felt that both Ellis's printed publications and his exsiccatae provided valuable American reference materials for later workers, and his generous personal assistance to his correspondents was a vital impetus to many beginning the study of fungi, especially the parasitic species. In turn, they named several genera after him: *Ellisia*, *Ellisiella*, *Ellisiellina*, *Ellisiodothis*, *Ellisiopsis*, and the previously mentioned *Elletevera*. Many species were named *"ellisii"* or *"ellisiana."* The long list of eponyms is an indication of the regard in which he was held by his coworkers.

Ellis's work was rooted in older European taxonomic tradition, to which he was introduced by Ravenel and which was furthered (sometimes unfortunately) by Cooke. He did not have the scientific training to go beyond the process of classification by morphology; consequently his determinations are inconsistent by modern standards. However, together with his colleagues Peck, Frost, and Morgan he represented the first generation of American workers to become independent of European taxonomists, thereby opening the way for the more scientific workers who followed.

The last word comes from that ruthless destroyer of mycological reputations, Curtis Gates Lloyd:

> It was my privilege to meet Professor Ellis during the latter years of his life. He was exceedingly timid and shrinking, but possessed of a charming personality, and by his lovable

> disposition endeared himself to all who knew him. I never went East without going to see him for a few hours, and always came away the better for the visit... While hampered by lack of published literature and museum facilities, he yet accomplished a vast amount of work, and did it as best he could. While I was aware of many mistakes that he made, I never, during his lifetime, mentioned one of them in print. So earnest and honest was he in his work, and possessed of such a lovable disposition, that it was impossible for me to say a word that might have hurt his feelings in any way. I do not know of any other person towards whom I have felt exactly as I did towards Mr. Ellis, but consideration for his sensitive disposition and the high regard in which I held him personally, prompted me thus to make of him an exception. (Lloyd, 1915)

LOCATIONS OF ELLIS MATERIALS

Ellis's Herbarium and library are mostly at New York Botanical Garden (NY); Everhart's sets of Ellis & Everhart species and exsiccatae are at Farlow Herbarium, Harvard (FH); correspondence to Ellis is mostly at NY, with some at the National Fungus Collections, Beltsville, Md. (BPI) and at FH. Letters from him are in the collections of the addressees: Farlow, FH; Peck, New York State Museum, Albany; Ravenel, Clemson College, Clemson, S.C.; Atkinson, Cornell University, Ithaca; Burt, FH. His microscope is at Cornell. His diary and personal correspondence are in the Vineland Historical and Antiquarian Society, Vineland, N.J.

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I'm most fortunate to have had so many enthusiastic -- and energetic -- people doing detective work on this obscure New Jersey botanist for my sake. They include Robert Peabody, who got me started; Dr. Elizabeth Moore, who introduced me to Newfield and its people; Anna M. Reid and friend Anne Taylor who tracked down the Ellis genealogy and in the process turned up much more; and in particular, Mary and Frank Smith of Newfield, who have combed the records (and attics) of the area with a diligence worthy of Sherlock himself. (They also arranged to have Mrs. Ellis's gravestone repaired.) I'm indebted to the Hunt Institute for Botanical Documentation for photographs and references; to the Vineland Historical Society, for permission to quote from the Vineland Historical Magazine, 1934 and for Figs. 1 and 2; to Tamara Haygood, for use of material from her dissertation on Ravenel; to New York Botanical Garden, for permission to use and quote from their archival holdings and for a most pleasant visit. And of course the published and archival resources of the Farlow Library made the project possible.

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THE CANADIANS JOHN MACOUN AND JOHN DEARNESS, AND THEIR CONTRIBUTIONS TO NORTH AMERICAN MYCOLOGY

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SUMMARY

John Dearness and John Macoun were contemporaries and shared an interest in mycology. Both were teachers, naturalists, avid collectors and carried on extensive exchanges with collaborators. Macoun travelled widely across Canada, wrote little about fungi, studied his collections only superficially and left us a rather small (a few thousand) collection of fungal specimens. Whereas Dearness never went far from London, Ontario, although he travelled many miles by bicycle in his area, published over 50 papers on fungi, recorded the microscopic features of his specimens, learned to distinguish a wide variety of species and left us a herbarium of about 27,000 well-curated specimens.

Mycological studies by North Americans essentially began in 1822 with Schweinitz's flora containing 1373 fungi of which nearly 320 were described as new. Subsequently his 1832 synopsis of North American fungi contained nearly 3100 species, over 1200 first discovered by Schweinitz, established the foundation of North American mycology. After Schweinitz died in 1834 it was 33 years before another American mycologist as active as Schweinitz appeared on the scene (Rogers, 1977; p. 9).

In 1867 C.H. Peck, botanist of the State of New York, began a mycological career that was to last 48 years. During that time he described over 2700 taxa of fungi (Gilbertson, 1962). In the late 1870's Peck was identifying fungi for John Macoun of Belleville, Ontario, Canada (see below) and this interchange is clearly one of the origins of Canadian mycology. Several other eminent mycologists studied Macoun's fungi but the greatest number were handled by John Dearness of London, Ontario.

This note will deal with these two Canadians and their role in North American mycology.

JOHN MACOUN, 1831-1920

Born in County Down, Northern Ireland, he emigrated with his mother, brothers and sisters in 1850 to Canada and soon settled in Belleville, Ontario. He worked on a farm and later owned a farm, however, in 1860 he became a teacher.

He was collecting and identifying plants by the mid 1850's but, "had not up to that time thought of drying them and making a collection" (Macoun, 1979; p. 33). His first contact with a professional botanist may have been in 1860 when he, "collected a few species this year which I could make nothing of, and sent them to Professor Hincks, of Toronto University, who named them for me" (Macoun, 1979; p. 37). In 1861 he commenced to form a herbarium (Macoun, 1979; p. 218) and, "began to collect every moss I could see, but I knew little about them" (Macoun, 1979; p. 38). And it would seem reasonable that his interest in fungi did not blossom until some years later.

In 1862 he and Ellen Terrill were married. They had three daughters and two sons. "After getting a home of my own in 1862 I at once commenced a more permanent herbarium" (Macoun, 1979; p. 39).

Macoun's reputation as an explorer, naturalist, etc. rests principally on a series of trips, the reports describing these explorations, and the collections he made during them. The first trip in 1869 was to Lake Superior. In 1872 he went across the continent from Ontario to Vancouver Island. Subsequent trips in 1875, 1879, 1880 and 1881 centered on Manitoba, Saskatchewan and Alberta. I have not seen any fungi collected on these trips and presumably none were preserved. However, in 1879 east of the northern end of Long Lake, Saskatchewan, (Macoun, 1979; p. 141) mentions the, "rich country which produced enormous mushrooms.... Lycoperdon (puff-ball) was seen that grew to a very large size and numerous others were noticed." This is the only place in Macoun's autobiography where he mentioned fungi. However, fungi are mentioned in the final chapters which were prepared by his son, W.T. Macoun.

In the autumn of 1882 he moved to Ottawa where he was a botanist with the Geological & Natural History Survey. He continued his field trips and mentioned that he never spent a summer at home. In early 1912 at age 81 he was partially disabled by a stroke. He then retired from the Survey and he and Mrs. Macoun moved to Sidney, Vancouver Island.

MACOUN'S FUNGI

Collections of fungi by Macoun can be found in several North America herbaria. The largest number, about 3000 specimens, is in the National Mycological Herbarium, Ottawa (DAOM). At DAOM these fungi are filed in two collections. One, comprising about 1800 packets, was segregated from Macoun's collections of plants and other cryptogams at the National Museum of Natural History, Ottawa (CAN). These collections were mostly made between 1890 and 1910, and were principally from the Ottawa area. In the autumn of 1905 he collected nearly 700 species in the vicinity of Ottawa (Macoun, 1979; p. 291). The earliest Macoun collection, I found, was dated 1878 from Belleville and a few are dated as late as 1916. By 1929 these fungi were in DAOM and John Dearness was, apparently under contract, studying all the specimens in order to confirm or revise the fungus names (pers. comm. F.L. Drayton and I. Mounce at DAOM).

The second batch of Macoun specimens, numbering about 1200, are in the John Dearness Herbarium (DAOM). They date from 1912 to 1916 and were nearly all collected in the Vancouver Island and the Vancouver area of British Columbia. These would seem to be the specimens mentioned by Macoun (1979, p. 300). Boivin (1980, p. 36) was of the opinion that these "Macoun's Fungi" were duplicates of fungi which were initially at CAN but this is not the case.

Several hundred Macoun specimens were forwarded from the Provincial Museum, Victoria, to the mycological herbarium at the University of British Columbia, Vancouver (pers. comm. R.J. Bandoni 1985). These fungi were collected after Macoun moved to Sidney, B.C. in 1912, and are probably some of the cryptogams referred to in his autobiography (Macoun, 1979; p. 301). There are Macoun specimens in the herbaria of mycologists he corresponded with. I have seen some specimens in the National Fungus Collections, Beltsville (BPI). These were sent by Macoun to either E.A. Burt at the Missouri Botanical Garden, St. Louis, or to C.G. Lloyd, Cincinnati (cf. Macoun, 1979; p. 300). And the Burt Herbarium at the Farlow Library and Herbarium, Cambridge (FH) contains some Macoun specimens, especially of corticioid fungi. Based on the lists of identifications sent to Macoun by C.H. Peck and J.B. Ellis, preserved in the Macoun correspondence at Ottawa, there must be several hundred Macoun fungi in each of their herbaria.

The first mention in print of Macoun's fungi appeared in "New species of fungi" by Peck (1879) where Paxillus hirsutus Peck and Polyporus macounii Peck were described as new from specimens Macoun collected at Belleville.

A considerable volume of Macoun's correspondence and his field notebooks have survived and are in the Public Archives of Canada, Ottawa. A microfilm copy, which was available to me, is in the library of the Museum of Natural History, Ottawa. The mycological items are dated from the late 1870's through 1918. A few pertinent excerpts are included here.

C.H. Peck identified several hundred fungi for Macoun. The earliest letter I noted, but apparently not the first, was on March 31, 1879 and Peck began "I have looked through the specimens...." This date establishes that Macoun was corresponding with mycologists before he became a botanist at the Survey. On March 4, 1903 Peck sent a list of identified corticioid fungi and polypores, and said, "I would be glad to have spems [specimens] of such Thelephoras as Burt may determine for you."

J.B. Ellis also identified several hundred fungi for Macoun. These are recorded on long lists from Ellis. The earliest correspondence noted, was dated 7 Jan. 1882 and the most recent letter was dated 29 Feb. 1892. On 8 Feb. 1884 Ellis stated: Prof. Morgan [presumably A.P. Morgan of Ohio] says 395 = *Boletus chrysenteron* Bull. And on November 29, 1888 Ellis wrote: I think you had better send Agarics & Boletes to Prof. Peck... I should like a *full set* of the Prince Edw [Island] Fungi for my herb.... At any rate do not fail to *send me* samples of *all* other things as I should like to see what you have found. Ellis & Everhart (1885) published a paper based almost entirely on Macoun's specimens.

E.A. Burt (1914-1926) cited numerous Macoun collections but no correspondence to Macoun has survived. The mention of Burt in a letter from Peck (above) in 1903 indicates that Macoun and Burt had earlier established correspondence. In Burt's file at FH the earliest letter from Macoun is May 1905.

John Dearness seems to have begun correspondence with Macoun in February 1887 but from then until early 1891 the topics were plants and bryophytes. About 1915 Dearness began receiving hundreds of Macoun fungi. The correspondence, I saw, was between Macoun's son, James, a botanist in Ottawa, and Dearness. John Macoun had retired to the west coast and, following his stroke, had trouble writing, thus he was apparently sending fungi to his son who forwarded them to Dearness and perhaps to others. It may be that John Macoun wrote few letters following his stroke in 1912, nevertheless I do not know whether any of the letters he received at Sidney have survived. In January 1915 James Macoun wrote Dearness, "I agree that any list of what he [John Macoun] has collected on Vancouver Island should include those sent to Lloyd [C.G. Lloyd, Cincinnati]. Dearness' reply mentioned, "Since Dr. Peck became unable to do any microscopic work I have assisted his successor with the micro-fungi." In October 1918 James Macoun wrote Dearness, "I saw my father in Sidney about a month ago ... he has done very little in fungi this year as he seems to have pretty well exhausted the Sidney field."

MACOUN'S CONTRIBUTION TO NORTH AMERICAN MYCOLOGY

Macoun was an enthusiastic collector of living organisms. In the botanical kingdoms, fungi were of interest to him but they ranked behind flowering plants, mosses, hepatics and lichens. He published only a few incidental notes on fungi (Table 1) and in these the species identifications were almost entirely attributed to others.

His forte was collecting and he supplied many eminent mycologists with specimens. The importance of his collections lies in the many collections which became type specimens of species described as new. For example, Dearness' papers in Mycologia (1916-1929) contain 19 new species based on Macoun collections and Burt (1914-1926) in his *Thelephoraceae of North America* described 20 new species from Macoun specimens. No doubt many more examples exist in the writings of Peck and Ellis, the other principal identifiers of Macoun's fungi. Macoun's collaborators recognized his efforts by naming 11 species after him (Table 2).

JOHN DEARNESS, 1852-1954

Born in Hamilton, Ontario in May 1852, he moved with his parents to the London, Ontario area in 1856. Dearness lived in that area the rest of his life. After teaching briefly in rural schools, in December 1874 he was appointed Public School Inspector of East Middlesex, a position he occupied for the next 25 years. In 1881 he and Harriet Emma Wilkinson were married. They had two daughters and a son. In the 1880's he became more and more interested in botanical studies. By 1887 he was sending plants to John Macoun for identification. About this time he started studying the fungi. In late 1899 he became Vice-Principal of the London Normal School, where he was a popular teacher. He, through extramural study, was awarded the M.A. degree in 1903 from Western University. In 1918 he became Principal of the Normal School and then retired in 1922. Shortly after the University of Western Ontario awarded him an LL.D. He was very active in local and Provincial historical, natural history, education and service clubs. In 1936 he was elected a Fellow of the Royal Society of Canada. In 1941 the Dearness Research Laboratory was opened in the Montreal Botanical Garden and in 1953 the city of London dedicated The John Dearness Home for Elder Citizens. Most of the facts given here were taken from Tamblyn's (1955) biographical sketch.

JOHN DEARNESS AND MYCOLOGY

Unlike Macoun who has had essentially nothing written about his mycological interests, several articles exist on the mycologist John Dearness (e.g., Parmelee, 1978; Rogers, 1977; Tamblyn, 1955). From these we learn that it is uncertain just when and how Dearness became interested in the fungi. He was contemporary of Ellis, Peck and Macoun, and perhaps their publications and correspondence contain some explanation. Only a few post cards and letters survive of the Dearness correspondence. He used some, perhaps most, of it for specimen packets. He was apparently self-taught and mycology was not his profession.

By 1889 Dearness was sending bulk collections to J.B. Ellis for inclusion in his exsiccati North American Fungi, which indicates that Dearness was already experienced in mycological methods (pers. comm. D.B.O. Savile, 1985). He probably had been collecting for several years and was sending entire specimens to Ellis. Ellis may have persuaded him to start his own herbarium. A search of all sections of the Dearness herbarium showed numerous collections in 1889 but none collected earlier by him (pers. comm. D.B.O. Savile, 1985). He began publishing jointly with Ellis on Canadian fungi in 1892.

The Dearness herbarium contains over 27,000 specimens, including over 420 type specimens (Parmelee, 1978). It is obvious that Dearness was a careful curator. Notes on microscopic features are filed with the specimens and there is an alphabetically arranged card index to the fungus names. In organizing the herbarium Dearness recognized nearly a dozen major groups of fungi (e.g., Uredinales, Polypores, etc.), thus all the rusts are together. The one quirk is that the species are filed by a species number that

Dearness assigned. Thus the first rust is number 1 and the first polypore is number 1. To find a particular species one looks in the index for the species number then the specimen can be located (Parmelee, 1978).

Dearness authored or coauthored over 50 papers on the fungi (Tamblyn, 1955) and described over 400 taxa as new (Parmelee 1978). His coauthors were Ellis, H.D. House of Albany, G.R. Bisby and A.H.R. Buller, both of Manitoba. Dearness corresponded with numerous mycologists, especially notable are H. Rehn, P. & H. Sydow, P.A. Saccardo, R. Ciferii, G.P. Clinton, Geo. Zundel, J. Faull and I.L. Conners (Parmelee 1978). As mentioned under J. Macoun (above), Dearness reworked in 1929 the Macoun fungi in DAOM, and had received and identified over a thousand additional specimens from Macoun from 1912 to 1916.

John Dearness' mycological studies spanned over 50 years (about 1890 to 1941). He was president of the Mycological Society of America in 1937 and was the first Canadian to receive international recognition.

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Table 1. The mycological publications of John Macoun (excluding Lichens).

1. Edible and poisonous fungi. Trans. Field Nat. Club, Ottawa 2: 62-67. 1884.

The text of a lecture given to the Club. A very general discussion of several common species and including, incidentally, some geographical records.

2. List of the plants collected on the coasts of Labrador, Hudson's Strait and Bay by Dr. Robert Bell in 1884. Report of Progress 1882-83-84. Geol. & Nat. Hist. Survey and Mus. of Canada, Montreal. 47 p. 1885.

Nine species (three determined only to genus), identified by J.B. Ellis, from Northwest Territory, Quebec and Labrador.

3. Note on the poisonous properties of the *Agaricus rodmani*. Ottawa Nat. 2: 142-143. 1889.

Specimens from Ottawa, Ontario were identified by C.H. Peck.

4. List of plants collected in Hudson Strait by Dr. Robert Bell in 1897. Ann. Rept. (NS) Vol. 11. Ottawa, pp. 34-37. 1901.

Fifteen lichens and two other fungi (*Scleroderma* sp. and *Lycoperdon belli* Peck) were collected around Prince George's Sound. "The Cryptogams determined by Prof. John Macoun."

5. Two rare fungi. Ottawa Nat. 19(9): 178. 1905.

Cyclomyces greenii Berk. and *Pleurotus subareolatus* Peck identified by E.A. Burt and collected in southern Ontario.

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Table 2. Species of fungi named after John Macoun (excluding Lichens).

Belonidium	*macounii*	Dearn.	(1916)
Clavaria	*macounii*	Peck	(1894)
Corticium	*macounii*	Burt	(1926)
Diaporthe	*macounii*	Dearn.	(1916)
Diatrype	*macounii*	E. & E.	(1890)
Fusarium	*macounii*	Dearn.	(1917)
Metasphaeria	*macounii*	Dearn.	(1916)
Polyporus	*macounii*	Peck	(1879)
Polystictus	*macounii*	Lloyd	(1914)
Rosellinia	*macouniana*	E. & E.	(1884)
Uromyces	*macounianus*	E. & E.	(1893)

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CHARLES McILVAINE

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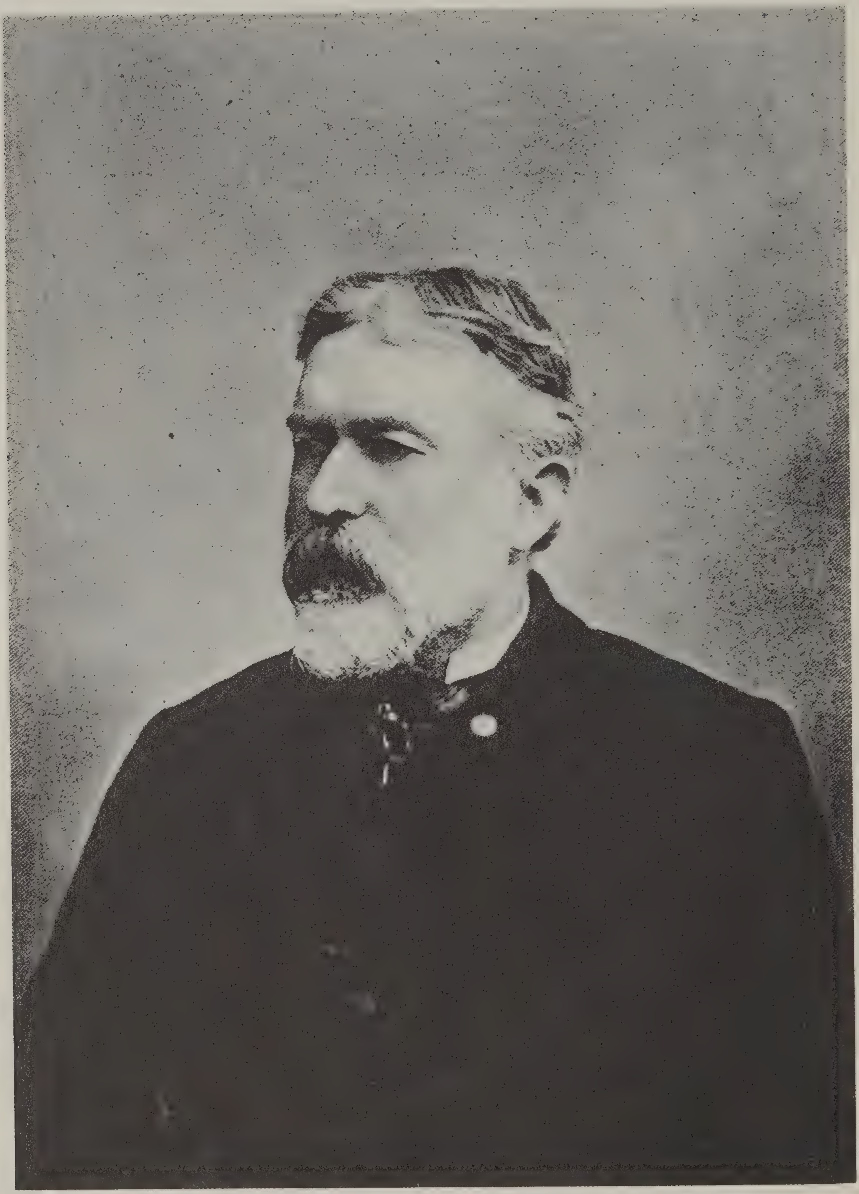
SUMMARY

Charles McIlvaine (1840-1909), a self-proclaimed amateur mycologist, added to our knowledge of edible and poisonous fungi by personally testing hundreds of American species. His correspondence with C. H. Peck and others led to the determination of many of the species in McIlvaines' One Thousand American Fungi, the most comprehensive book on American fungi at the time of its publication. He lectured widely on mycology and mycophagy in such venues as the Chautauqua centers in New York and Pennsylvania. He did more than anyone else of his time to popularize mycology.

(Summary prepared by Symposium editors)

America at the turn of the century was a land of great, if less than pure, vision. In the east, the robber barons built massive fortunes in industry, while traveling evangelists held tent meetings to save the souls of the less fortunate. As the western frontier closed, the mysteries of the natural world became the new frontier for many. Ladies in long skirts and gentlemen in spats searched the woods for biological curiosities. Mycology was still a fledgling science, often conducted by the general botanist as a sideline. Against this background Charles McIlvaine (Figure 1) emerged as the hero of American mycophagy. His experiences with professional botanists, with doctors and pharmacologists, and with the public, provide insights into the amateur-professional relationship as it has developed in the United States.

Although McIlvaine remained a self-proclaimed amateur, he nevertheless deserves a place in the history of American mycology. His One Thousand American Fungi (7), based on a solid collaboration with Charles Peck and other professional mycologists, was an ambitious attempt to gather together the existing literature on American fungi into a comprehensive, illustrated treatment. Motivated



Charles McIlvaine

partly by patriotic fervor, partly by scientific conviction, he emphasized the work of American authors, rather than British or European authorities, in systematically organizing published descriptions of American fungi. The uniqueness of his treatment stems from his campaign to test through personal experience or that of his friends actual edibility of a broad range of fungi. As a reference on edibility, One Thousand American Fungi has remained an important resource despite the passage of nearly a hundred years.

McIlvaine, a colorful and flamboyant figure, generated a vast public enthusiasm for the study of mushrooms through his speaking and writing. Because of the popularity of his Chautauqua talks, McIlvaine probably presented mushroom lectures to more people than anyone else in the United States, a record of which he would have been inordinately proud. One of his primary goals was to combat fear of experimentation with eating fungi, which he felt was inherited largely from English prejudice. From 1881 until his death in 1909, McIlvaine spend almost all of his time in a campaign to interest the public in mushroom lore.

Surprisingly, McIlvaine's interest in mushrooms did not begin until he was nearly 40. How did his fascination for mushrooms develop? After McIlvaine's death, Dr. Howard Kelly of John Hopkins School of Medicine became intrigued by the mystery surrounding McIlvaine's life and collected letters from those who had known him in an attempt to answer this question. Those letters, now preserved in the University of Michigan Herbarium Library, together with the Peck-McIlvaine letters at the New York State Museum in Albany, paint a fascinating picture of a man whose interest in mushrooms led him to make a significant contribution to American mycology. From these letters also emerge hints of a personal life complicated by marital and financial difficulty. Harshberger (5) and Bowser (3) provide other details of McIlvaine's life.

EARLY LIFE

Charles McIlvaine was associated with American botany from the beginning of his life: his father's estate in Chester Co., Pennsylvania, adjoined Bartram's Garden, the home of the esteemed American botanist John Bartram. In 1840, the year Charles McIlvaine was born, his father Abraham served as a member of the Electoral College of Pennsylvania, casting his vote for Harrison for President. In 1842, Abraham McIlvaine was elected to Congress on the Whig ticket, opposing Harrison's conduct of the Mexican War.

As a child, Charles McIlvaine attended public and private schools in Chester County, withdrawing at the age of 13 because of ill health. An avid reader, he continued his education privately; as an adult, he often referred to himself as self-educated. When the Civil War broke out, McIlvaine was serving as Division Engineer on the East Brandywine and Waynesburg Railroad. Although barely 21, he mustered a company of volunteers for the Union cause. Company H of the 97th Regiment of Pennsylvania Volunteers elected

McIlvaine their captain, a title which he continued to use freely throughout his life. After two years, McIlvaine again found himself in ill health and retired from the service. In 1864 he married Sarah Gibson McIlvaine, a distant cousin. She died in surgery in 1891; there were no children.

For many years McIlvaine served as a consulting civil engineer in West Virginia, North Carolina and New Jersey, working for men "who want the Truth about roads they are interested in" (McIlvaine to Peck, October 23, 1893). His roadbuilding trips took him into wilderness areas, where he began to notice mushrooms growing in the woods and on railroad ties. Curiosity about natural history led him to many observations about plants and animals which he later published as short stories or as part of One Thousand American Fungi.

In 1873, at the age of 33, he went abroad. While in the company of European artists and sculptors, he began his writing career, sending articles on art criticism to American newspapers. By 1881 McIlvaine, under the pen name of "Tobe Hodge", was a recognized author of humorous sketches for the Detroit Free Press and for magazines such as Lippincott's Monthly Magazine, Puck, Judge, Harper's, and the Sunday School Times. During this period he invented printer's copyable ink. An autobiographical letter, found among McIlvaine's books after he died, mentioned modestly that this invention, which "revolutionized commercial and railroad printing", was one of the accomplishments for which he especially wished to be remembered.

McILVAINE'S CAMPAIGN TO TEST EDIBILITY OF MUSHROOMS

McIlvaine described his introduction to mycophagy with characteristic hyperbole. While working as a civil engineer in the mountains of West Virginia, he reported:

> I selected a species which, in every way, invited me to a feast. It was golden yellow, lily-shaped, white in flesh,... and seductive in the smell of ripe apricots. It grew in fascinating clusters, where beech trees mottled the ground with shadow... Filling my saddle pockets I took them home, cooked a mess, ate it, and in spite of the prophecy of a frightened family, did not die (6).

Soon he had added fifteen or twenty new species to his personal list of edible fungi, without the benefit of identification. When a Philadelphia librarian sent him a copy of Badham's British Fungi, he discovered that he "should have died several times". Examination of works by other British and European authors led to a similar conclusion, and McIlvaine decided that he would personally test American fungi for edibility and report the results.

McIlvaine's enthusiasm occasionally led to unorthodox projects. He disagreed so strongly with the conclusions about edibility of mushrooms in a series of pamphlets published by Thomas Taylor of the U.S. Department of Agriculture in 1893 that he sent a 50,000 word piece to the New York Tribune entitled "The Protest of a Mycophagist." His campaign to further the study of fungi led him to suggest to Thomas Updegraff, a member of the House of Representatives, that he propose an amendment to the Army Appropriations Bill requiring that soldiers be taught to distinguish edible fungi (Updegraff to McIlvaine, Sept 26, 1893). McIlvaine's zeal in promoting mycophagy also resulted in schemes to propagate mushrooms; one involved disseminating wild Russula by planting the insects associated with them as a natural source of fungal spores (7; p. 185).

McILVAINE'S METHODS

McIlvaine's method of testing the edibility of fungi was to taste a little of the raw fungus without swallowing and register the effects, then to cook a little and do the same, and finally to cook and eat a larger piece. If his was successful, he ate an entire meal of the fungus and urged his friends and "undertasters" to sample it. Particularly at the beginning of his career, he was willing to test edibility prior to determination of the species.

Since he believed that the only deadly fungi were in the genus Amanita (and that the antidote was atropine), he felt relatively free to experiment in other genera. The antidote that he recommended for milder mushroom poisoning was an emetic followed by a glass of sweet oil and whiskey.

Many of the fungi that McIlvaine claimed to have eaten successfully have now been documented as poisonous. For example, he sampled species of Inocybe, Clitocybe, and Tricholoma with impunity, declaring these to be groups without poisonous species. How did he escape unscathed? Actually, by his own admission he was seriously poisoned on several occasions. His sampling, however, was not as wanton as is sometimes believed. If a species was cited as deadly, he observed extreme caution. Many species he avoided altogether. In the case of Gyromitra esculenta, which he ate regularly but in which poisoning occurs only rarely, he was just lucky.

In McIlvaine's era, there was little published documentation of mushroom poisoning in the United States. In the absence of data to the contrary, McIlvaine felt justified in calling a fungus edible if he and his friends could eat it safely. Today, with more data available, the statistical sample is larger, and therefore the chances higher that a particular species will have caused occasional poisoning and therefore be considered poisonous.

McIlvaine was an avid collector who made critical observations and took careful written notes. He also painted many of his collections. For accurate determination, he sent specimens to professional mycologists, most notably Charles Peck. As his interest deepened, he began to use a numbering system for collections but did not actually preserve specimens. Perhaps the most important influence on McIlvaine's work was his collaboration with Charles Peck.

CAPTAIN McILVAINE AND CHARLES PECK

In October 1893, shortly before moving from Haddonfield, New Jersey, to Philadelphia, Capt. McIlvaine was referred by his good friend Robert Macadam (not, alas, the creator of the road-building process by that name, John L. McAdam, 1756-1836) to Charles H. Peck. Their correspondence documents the growth of McIlvaine as a mycologist, as Peck instructed him in the literature and methods of mycology. With the first of many letters to Peck, McIlvaine sent *Mycena alcalina* specimens for determination. In the second letter McIlvaine asked for Peck's assistance in publishing a list of edible and non-edible fungi, together with a "small handbook", which seven years later became *One Thousand American Fungi*. When Peck agreed to assist in determination of specimens, McIlvaine wrote, "You of all men are the greatest classifier". McIlvaine was pleased with Peck's prompt replies to his requests for information and became intensely loyal to Peck.

In the beginning, Peck chided McIlvaine for eating fungi whose identity he did not know. By 1894 McIlvaine claimed to have eaten full meals of 436 different kinds of fungi, of which he was convinced that eight were probably deadly. Peck confided to a mutual friend (Peck to Sterling, June 22, 1899) that he thought this claim was probably excessive in numbers of species eaten.

Over the next seven years, the McIlvaine-Peck correspondence continued, averaging three letters a week during the collecting season. McIlvaine thought nothing of sending fresh specimens through the mail, considering them late if more than two days were required for transit from Philadelphia to Albany. He sent descriptions and sketches if fresh material was not available.

As the correspondence developed, so did McIlvaine's acumen as a mycologist (4). Peck conveyed the basics of nomenclature, instructions for writing descriptions, and opinions about color nomenclature. He also encouraged McIlvaine, saying that he put more faith in his actual experience than in the assertions of European authors. After a year of correspondence, McIlvaine wrote "You know and I know the desire of botanists to declare new species. Pride enters largely into it. Such men as yourself and myself should work to suppress multiplicity of species" (October 15, 1894). In 1897 McIlvaine penned a critical review of Peck's latest publication, ending the letter, however, with praise of Peck's mycological ability. Through the fifteen years of their correspondence, McIlvaine continued to stress his theme of the edibility of many of the fungi thought poisonous by European authors, particularly red-tubed boletes and all bitter or peppery fungi.

Peck's influence on McIlvaine was marked. McIlvaine was particularly pleased when Peck named a number of new species on the basis of material collected by McIlvaine (8). Shortly after McIlvaine's death, Peck wrote "Though I had the pleasure of meeting him personally but once and then had but a short interview with him, we had considerable correspondence and I learned to esteem him and count him among my friends" (Peck to Sterling, March 30, 1910).

THE PHILADELPHIA MYCOLOGICAL CENTER

With his friend E. B. Sterling in 1897, McIlvaine founded the Philadelphia Mycological Center, which he claimed was the first mycological club in America (a claim disputed by the Boston Mycological Club). Through this organization McIlvaine gained many of his "undertasters" who aided him in his systematic studies of edibility. Weekly walks in the woods resulted in the collection of fungi which piqued his curiosity and increased his acquaintance with mushrooms. For the Philadelphia club, McIlvaine developed his basic lecture on edible and non-edible fungi, which he delivered widely.

At this time he began to deliver talks to physicians and pharmacologists and to enlist their help in conducting toxicology experiments on animals. Professor Chitenden of Yale, Dr. W. S. Carter of the University of Pennsylvania, and Dr. J. P. Arnold of the University of Texas used McIlvaine's specimens to test toxic effects of mushrooms on dogs, frogs, and other animals. In Philadelphia, McIlvaine became involved in a number of mushroom poisoning cases, including a celebrated case in which Count DeVecchi was poisoned by *Amanita muscaria*. As a result of these cases, McIlvaine was elected an honorary member of the Salem County Medical Society and the Gloucester County Medical Society in New Jersey. McIlvaine also maintained a private home for the insane and cultivated the company of psychologists.

CHAUTAUQUA: MT. GRETNA, PENNSYLVANIA

As McIlvaine's fame as a speaker spread, he was invited to lecture at the summer Chautauqua series at Mt. Gretna, Pennsylvania. The Chautauqua was a broadly based experiment in resident adult education with strong religious overtones (2). McIlvaine lectured on edible and poisonous mushrooms, giving scientific information as well as recipes. He traveled to other points on the Chautauqua lecture circuit, lecturing once to 3000 at the New York Chautauqua, to 1500 at Shenandoah, Pennsylvania, and once to an audience of 475 cooks (McIlvaine to H. I. Miller, April 7, 1899).

Inevitably, his reputation as a Bohemian clashed with the strict environment of the Chautauqua. To begin with, alcohol was strictly forbidden, and this was McIlvaine's self-acknowledged weakness (S.N. Rhoades to Dr. Kelly, Jan 14, 1919). Second, the ambiguous circumstances of his second marriage to Ida Hawkins (between 1891 and 1897 he married his second wife, Ida Hawkins, whom he met through her father, a Civil War acquaintance. By 1897, however, his household consisted of himself, his housekeeper Mrs. Montgomery and a secretary, Miss Moelling) led to his expulsion from the Chautauqua by the clergy (C. R. Orton to Dr. Kelly, Feb 1, 1919) and compelled his move, together with his housekeeper and stenographer, to another state (M.V. Easton to McIlvaine, Feb 16, 1900).

PUBLICATION OF ONE THOUSAND AMERICAN FUNGI

In the midst of the controversy surrounding his move from Mt. Gretna, McIlvaine persisted in attending to the final details surrounding publication of One Thousand American Fungi, which appeared in 1900. Described as "sumptuous", the book cost $10,000 to publish, $3,200 for the color plates alone (McIlvaine to Peck, June 12, 1899). The author's edition of the book was almost totally subscribed before publication. Two years later a second edition appeared. Robert Macadam, who was cited as co-author, acutally had little to do with the final form of the publication, although he helped in editing the initial versions of the manuscript. Macadam had amassed almost 21,000 American species citations based on older works (still preserved at BPI) in anticipation of compiling an "American Sylloge" comparable to that of Saccardo, but was overruled by McIlvaine's decision to omit such citations. At the time of its publication, the book contained a greater number of descriptions and figures of American fungi than had been collected in one volume up to that time (1).

Although McIlvaine used descriptions by Fries, Stevenson, Massee, and Morgan, by far the greatest majority of the descriptions in One Thousand American Fungi were those of Peck. In fact, McIlvaine felt that the format for species descriptions should be standardized, and that Peck's format should be adopted by all mycologists. Peck's congratulatory letter on the publication of McIlvaine's book, although short, was treasured by McIlvaine above all other comments on the book's publication.

CONCLUSION

After a brief stay in North Carolina, McIlvaine and "the ladies", Mrs. Montgomery and Miss Moelling, moved to the banks of the Choptank River near Cambridge, Maryland. McIlvaine continued to live as he had since 1880 on his military pension, supplemented by the kind gifts of friends. Although he collected mushrooms from time to time, his activities consisted mainly of kitchen farming and writing short stories on natural history for children. In 1909 he died, not of mushroom poisoning but of arteriosclerosis. To the dismay of his friend E. B. Sterling, a McIlvaine obituary never appeared in the mycological literature (Sterling to Peck, July 10, 1910). His fame, however, has endured among mycophagists, of whom he said, "When once a person is inoculated with the virus of toadstool eating, all gratitude, friendship, even family ties vanish, and he or she will race for an edible toadstool, if but seen through a telescope" (6).

ACKNOWLEDGMENTS

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MYCOLOGY, UNIVERSITIES AND 19TH CENTURY AMERICAN SCIENCE

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SUMMARY

The work of American mycologists prior to the 1870's was by non-professionals working in the descriptive tradition of Fries and Persoon. W. G. Farlow transferred the high standards of Anton DeBary, working in Europe to North American academe. It was only after a university scientific community developed that ongoing advancement of science was possible in North American mycology.

(Summary prepared by Symposium editors)

> "History being an empty house without owners, a
> practical man may get in by the privy stones."
> MacLeish, Fresco's for Mr. Rockefeller's City

I shall ask you to draw back a bit from the worship of the local heroes in mycology and look at the nature of mycology and the way it was practiced in North America in the 19th century. For perspective, it is important to remember that it was not until 1861 that the fungal nature of disease in plants was finally demonstrated experimentally, that spontaneous generation was still being talked about, at least involving fungi, until into the 1840's and beyond, that cotton plugs, petri plates and commercially available autoclaves were the technological advances of the 1870's. DeBary in his textbook in 1866 introduced the system of classification which, with some changes, we use for fungi still. Darwin's Origin of Species also dates from mid-century. Revue Mycologique was the first mycological journal to be published when it began in 1879. And it should be remembered that all of this work was done in Europe. Science, or at least Botany, of the 19th century in the Americas was derived or grew primarily from work done in Europe. Workers from the great academic centers of Europe dominated science through a good part of the century. Their approaches and methods can be seen, at least in certain respects, in the activities of North American scientists.

I wish to discuss the nature of that derivation, the extent to which it may have influenced the manner in which American workers undertook their subject, and the ways in which the European ideas and ideals of the science were transported to North America.

Perhaps no man had more influence on mycology, particularly descriptive mycology, in the 19th century than did E. M. Fries, the Swedish botanist. He and, to some extent, C. H. Persoon set the stage for a century of descriptive work in mycology. Both provided brief but uniform descriptions of the fungi of Europe and some extra-European descriptions. Both provided descriptions to which fungus specimens could be compared. That Fries became the dominant author of the period can hardly be denied but the reasons are perhaps complex. Persoon, who was widely-versed in, and some might say, had a better grasp of some groups of fungi, was older than Fries. He lacked an academic connection and the luxury of a paying job. As a member of an important university, Fries had the advantage of a position and salary and was also in the eye of the public. He began publishing at an early age and continued to do so throughout his long life. He met and/or corresponded with North American mycologists spanning the greater part of the century from Tuckerman and Curtis near the beginning to Farlow at the end. He introduced the use of spore color in the Agaricales as a salient feature of the classification scheme which is followed to the present day. He worked on all groups of fungi or at least wrote descriptions of them, and thus his various works took on the aspect of compendia. He provided a uniform system of classification which was taken broadly and for which some amateurs feel such an affinity that they would like to return to it even today. Because of the connections between Fries and American workers, the descriptive tradition demonstrated by the Americans can largely be traced to Fries. Significantly, the work of American mycologists until the 1870's was done outside academe. I say significantly because it has probably influenced the direction of descriptive mycology ever since.

William G. Farlow discussed the difficulties of descriptive work in a paper in 1887:

> "One weak point in our botanical work has been that too many persons have attempted to write on descriptive subjects. Strange as it may seem to some ears, it appears to me that histological and developmental work is what is best adapted for non-professional botanists, including those who do not devote their whole time to the subject, and who as a rule have not sufficiently complete libraries and herbaria to enable them to do descriptive work well. This does not apply, of course, to the older generation of botanists, few of whom have had the training necessary for histological work, but it does apply to the younger generation. Inasmuch as the larger libraries and collections are in the colleges and larger cities, descriptive work, if it is not to be shabbily done, must be done by persons connected with

> colleges, or by those who are so situated that they can easily visit herbaria and libraries. Furthermore, descriptive work should be in the hands of a comparatively few experts, for long experience is necessary to a good result...."

Thus, by the end of the century Farlow was arguing that the descriptive work should be "institutionalized" and he implied that earlier work was not as high in quality as it should have been because of the lack of reference tools.

If we look at the roster of 19th century American mycologists (and I include Edward Tuckerman), they share some common traits. Their approach is derived for the most part from the same source, the Fries-Persoon tradition. That tradition is best expressed perhaps by saying that it is non-biological (that is to say that the collections could be worked on and examined dry as well as fresh), that the terminology and methods of description were largely drawn from the vocabulary of phanerogamic botany, that geographical distinctions were held to be important as species indicators, that descriptions were, short with little attention given to microscopic detail, and that none provided new or innovative classification systems. If one looks at the papers and descriptions of Tuckerman, Ravenel, Frost, Curtis (and Berkeley), Ellis, Peck, Morgan, Schweinitz, in short, most any of the mycologists of the early to midpart of the 19th century, they share these characteristics. This is not to say that the Europeans were not producing similar treatments but it is especially those outside the European academic tradition who did so -- Berkeley, a cleric, and M.C. Cooke continued the tradition in a non-University post at Kew until the 20th century. Montagne in Paris would join the ranks. The work of categorizing the fungi of North American needed to be done, as it still does; by some of these men it was admirably done but we should keep in mind that it was a cataloging program and was not innovative by nature. The work it generated was destined to require re-evaluation, as the number of type studies which have been done recently indicates.

The descriptive work of the 19th century led to a series of papers on fungi of particular areas and, as I stated, most of them were highly dependent on Europeans -- Fries, Berkeley, and later, Cooke, in particular. The reason for the dependence is several fold. First, it is a matter of necessary materials as Farlow indicated. The books on the subject, let alone the access to specimens for comparison, just did not exist in North America. The largest fungus collection even in 1850 was probably the Schweinitz herbarium in Philadelphia which was not much more than a collection of types and unverified records. A comprehensive mycological library did not exist. Books were in private hands or were scattered in institutional libraries. Secondly, there was a lack of training. Schweinitz received his training in mycology with his religious training under Albertini. Those who followed had no experts on hand. Few North American botanists were undertaking taxonomic studies other than those involving phanerogamic plants (save Sullivant, a businessman in Columbus, Ohio, who did the pioneer work on the mosses in North America and who sent fungi to Montagne in Paris, which were labeled as being from Colombia). There was Torrey who did the best he could with the non-flowering plants but for whom the vascular plant flora of North America was of greatest importance, the erratic Rafinesque, Nuttall, William Dandridge Peck (at Harvard), and a few others, none of whom showed interest in fungi. Asa Gray set up shop at Harvard in 1842 and brought phanerogamic botany into flower at one of Americas's great Universities. As advisor and a source of encouragement, he brought to the study of botany people who could undertake various of the groups of plants. He corresponded with, prodded and scolded Curtis, Tuckerman, Sullivant, Ravenel and others and he soon realized that what he needed to do most was to encourage others to take up cryptogamy. Gray realized that the self-instructed enthusiast could not carry on by himself without training and resources. And thirdly, the possibility of being a professional botanist did not present a sweeping vista of opportunity. Gray had an M.D., Curtis was a minister, as was Schweinitz; Tuckerman had degrees or worked in several fields, Ellis taught school, Frost made shoes, Morgan taught school, Ravenel had businesses, but C. H. Peck alone had a professional position. Botany was secondary to most of these men by the 1860's because the pressure to make a living came first. Not until Agricultural colleges were instituted and came into prominence in the 1870's did a job market for mycologists materialize. To summarize, the lack of resources, lack of training centers, and no job possibilities were determining factors in the shaping of mycology in the 19th century. It is no wonder that most of the work took place in isolation and that it was done by people who became consumed by their hobby, but the obligation of the hobbyist is very different from the obligation of the professional.

> Farlow (1887) had quite a lot to say about amateurs:
> "The amateur abounds more with us than in any other country with the exception of England. We have an immense variety, from the gay and gallant young man who is going to do something for science, but who now can barely pay his club expenses in winter and run a steam-yacht in summer, down to the impecunious ignoramus who informs you that he is going to write a book, to include all the fungi of this continent, and coolly asks you to give or lend him all your books and specimens, and tell him how to begin. We have the male bore, who kills our time by forcing us to help him kill his; and a copious supply of mild-eyed, sweet-tongued women, whom we can not scold, because they are conscientious, and whom we can not get rid of, because they really have no other amusement. But the botanist has a slight twinge of conscience when he thinks that the kinds of amateurs of which I have spoken are tolerated mainly in the hope, sweet but prolonged, that they may contribute funds to some botanical endowment. But, alas! the gold-mills of the amateurs grind slowly, and they grind exceedingly

> small. The large sums seldom come from amateurs, but generally from hard-headed business men who do not pretend to be botanists, but who, with a liberality which does infinite credit to us as a nation, give their money for the public good. It is superfluous for botanists to express their admiration of this class of liberal men. We more than admire them -- we live on them!
>
> But, fortunately for botany in this country, we have many amateurs of another class. We have many men and women, rich in intelligence, but usually not rich in money. They are scattered all over the country. They are to be found on the coast of New England, in the smaller towns of the West and South, and in the still more recently settled coast of the Pacific. The time which they can spare from their necessary and not infrequently arduous occupations is given with enthusiasm to botanical pursuits. The spare money which they can command is spent on botanical books which they read. Their collections do not lie idle on the shelves. It is such amateurs as these of which we may justly be proud, and it is by their labors that a large, if not the largest, share of our botanical investigations must be made in the near future, and it is of the greatest importance that their energy and enthusiasm should not be misdirected. In the remoter districts, as I have said, the absorbing work, for some time to come, must be the collecting of specimens and the accumulation of field notes. In the older parts of the country, including even the Mississippi Valley, it seems to me that the rising generation would make the best use of their opportunities by working out some of the many important questions of histology, and in studying the life-histories of different plants, more especially cryptogams. But the main point is, not to attempt to do too much." But, what was attempted?

The bulk of the work of the last century may be characterized as descriptive, that is, descriptions were provided for the fungi found. The descriptions were, for the most part, simple, with reference to the overall construction of the spore-producing structure and with spore measurements being the main quantitative date to be provided. The articles presenting the data were sometimes illustrated but more often were not. The scope of the work was often regional and the authors writing them often had only had experience with the fungi in a limited region. They were often "sanctioned" by a European authority if not co-authored by one. If one is looking for the reason that we, as mycologists, are often troubled by early descriptions, the difficulty may be sought in the writers' lack of experience with fungi from other areas, the brevity of description and the lack of quantitative data. There are qualities which are shared with the Friesian descriptions followed by American authors. Non-taxonomists and non-mycologists might well be surprised to look at the work of Fries and Persoon and realize how little information is contained in the descriptions of the formerly accepted "starting point" books. I give examples here and comparisons because I wish to remind ourselves of what we have to work with.

Persoon wrote a description of *Peziza aurantia,* one of the more prominent operculate discomycetes, in the *Synopsis methodica fungrorum* (1801) as follows:

> 21. Pez. aurantia: acaulis cespitosa dimidiato - flexuosa aurantia externe albida. *Obs. myc. 2. p. 76. Schaeff. fung. t. 148. Fl. dan. t. 657.*
>
> Helvella coccinea. *Bolt. fung. t. 100.*
> Peziza coccinea. *Bull. herb. t. 474.*
> Autumno ad radices trunci putridi quercini elegans haec species crescit. Valde fragilis, hinc saepe partita invenitur. Terrestris, *sessilis*.

Fries in 1821 in the second volume of the *Systema mycologicum* wrote of the same fungus:

> 16. *P. aurantia,* subsessilis, irregularis, obliqua, aurantiaca, extus subpruinosa albida. [there follows a paragraph of citations to previous literature on the fungus]
>
> Colore nitidissimo oculos e longinquo aldicit, inde a plurimus auctoribus notata. Primo integra, dein flexuosa & contorta, 1-2 unc. lata, extus leviter flocculoso-farinosa, margine primo subtiliter villoso. Hinc parum heteroclita in hac tribu (etiam ex analys. Nees. l. c., sed parum nimis aucta videtur). Tournefort. Dillenium (Cat. giess.) Michelium (N. gen. p. 206 n. 13). *Ad radices truncorum Quercus & Fagi, frequens. Etiam in Pensilvania. Autumno.* (v. v.)

These descriptions, I hope, make the point that little information other than color and general form are mentioned. They also point out that the reliance on literature, that is, a sense of priority, was important to Persoon and Fries. It is this aspect which is most lacking in the descriptions prepared by mycologists of the 19th century and certainly was the most difficult aspect for an American to deal with. The characteristics of the ascospores, which are so striking, are not discussed in either description.

To represent the American contribution to this type of description, I cite Peck (29th Report of the State Museum p. 54. 1878) using his description of *Peziza bronca*:

> Peziza bronca n. sp.
> Cups gregarious or crowded, sessile, subhemispherical, four to nine lines broad, whitish or very pale-buff, externally roughened by small crowded whitish

> warts; asci cylindrical; spores elliptical, one to two nucleate, .008' - .0009' long, .0005' broad.
>
> Ground. Knowersville and Sandlake, July and August.

Changes are evident only in that spore measurements were given. But it is interesting that in more recent studies of this fungus, it was found that two size classes of spores were present in the apothecia. The change in descriptive terms other than the switch to English can hardly be deemed radical.

Radical change did occur in mycology in the 19th century. It came about when William G. Farlow entered the scene. Farlow, the son of a railroad president, was a Harvard undergraduate and became Asa Gray's assistant after having completed his work on a medical degree. Gray encouraged Farlow to study plants as a profession, though he had advised the security of a medical degree. After a few years of assisting Gray, Farlow was sent or decided to go to Europe to study cryptogamy. Gray wrote to Alphonse De Candolle in 1872: "My youthful assistant of the past two years goes in a week or two to Europe, to study in ... Strasburg.... He takes a fancy to cryptogamia. His name is Farlow, an honest, good fellow." The intentions of both Gray and Farlow were very clear. Farlow was to become the person in North America to take up the study of cryptogams. Once in Europe Farlow traveled a great deal and was fortunate to have settled for the longest part of his stay with Anton DeBary. DeBary represented the foremost mycologists in Europe but he was not of the descriptive tradition. DeBary was an experimenter. Ainsworth noted that he had cited DeBary in every chapter of his book. He solved the potato blight problem once and for all, he worked out the life cycle of stem rust of wheat, he observed nuclei in fungi, he described the movement of zoospores; in short, he approached fungi as living organisms and was able to induce them to jump through hoops in the laboratory. He represented a tradition quite distinct from that which has been discussed above. He wrote a textbook which had great impact on the teaching and the study of mycology. Farlow himself recorded the approaches of the lab:

> "A fortnight ago Dr. Schmitz gave me a Lycopodium selago to study and, after making sections and preparations of one kind and another, I thought I knew it pretty well when DeBary asked whether the capsule arose from the stem or the leaf. After two or three day's work I managed to get sections which satisfied him and, of course, myself, that it arose from the leaf. Then came the question how it arose, which he didn't know or, as far as I can find out, any one else. After much more labor, I discovered that the epidermal cells begin to divide parallel to the surface and it grew out in that way. Then came the, to me, transcendental question: what might the subepidermal cells do?, and for a week, I made section after section of the Vegetationspunkt with no results whatever till I used up a great bottle of

> material which put a stop, fortunately, to further investigations. I ventured to suggest to my neighbor that I thought, as I wasn't to stay in Europe forever, that my time might be better employed than searching for a needle in a haystack which I could do as well at home. My Alsatian friend, from whom I learned more than anyone else, said Oh! in a few months you will be able to write a monograph on the subject. That remark was a clue to the whole thing."

The influence and the impact of the experience Farlow had with DeBary can hardly be overestimated. Farlow wrote to Gray that he was going "to catch the plan of work in different places and then myself to transfer that plan to America." Farlow himself did little in the way of descriptive mycology, though his work on the marine algae certainly falls into the descriptive category. He built a collection which any European would be proud of, which included both books and herbarium specimens. He offered training in the field of cryptogamic botany which is probably unequalled even today, and he brought to his subject a world view which was missing in the early workers in this country. Though there is little that is truly innovative in his work, it is thorough, and his bibliographic work is important in that it set a high standard of reliability. That Farlow succeeded in transferring the DeBarian method to North America can hardly be denied. A single paper can be used as an example. In 1876, while still on the staff of Harvard's Bussey Institution, Farlow wrote a paper "On the American grape vine mildew." Using the same methods employed by DeBary, Farlow studied the disease which caused minor damage to the native New England grape. He noted zoospore swarming and in fact used the material in class demonstrations. Prophetically he noted that if the disease were introduced into Europe, it might have serious results. E. C. Large in the Advance of the Fungi said: "DeBary's classical experiments, which had been a nine days' wonder during the 60's were being repeated year after year now by Farlow's students, as a regular part of their course. Science was moving west."

Farlow's views of European science in comparison with American science were clear. He wrote (1887):

> "In a new country the first work must be almost entirely descriptive and classificatory; and, when this work has reached a sufficiently advanced stage, histology, physiology, and study of life-histories assume more and more importance. In most European countries the first stage has been long past, except as far as some of the lowest forms of plants are concerned, and the greater part of the best work of France and Germany at the present day relates to physiological and developmental subjects. Where do we stand? The question is important, because there is not infrequently a tendency to assume that work in this country is of value only in so far as it is on the same plan and of the same kind as

> work in Europe. We must be contented to wait a little while, and we do harm rather than good if we teach that there is no work worth doing except that done in the laboratories of Germany. It often seems as if we were producing a set of precious little prigs, when one sees young men turning up their noses at all those who do any work not involving the most complicated microscopical manipulations. It is well to have our standard high, but it should not be unattainable.... One young man thinks he can't do any work because he has not a Jung microtome. Another has been unable to do anything during a vacation at the sea-shore because he had not osmic acid. To such persons one is inclined to say that he would be thankful if they would do anything."

It is my feeling that Farlow's students were trained to do important original work and, under his leadership, produced some of the most important mycological studies of the century to follow. If one compares the work of Roland Thaxter on the Entomophthorae of North America (his thesis) with the descriptive work of others who were his contemporaries, it is startling -- clear detailed description of microscopic fungi based on original collections and on important reference collections and the literature (Thaxter's other work is, of course, equally remarkable). If one looks at the types of papers Farlow and his students were writing by the late 1880's, one can see the divergence from previous work. The titles of some of these are listed, following:

George Howard Parker, On the Morphology of Ravenelia glandulaeformis.

Roland Thaxter, On Certain Cultures of Gymnosporangium, with Notes on their Roesteliae.

Benjamin Lincoln Robinson, Notes on the Genus Taphrina.

William Codman Sturgis, On the Carpologic Structure and Development of Collemaceae and allied Groups.

Charles Louis Mix, On a Kephir-like Yeast found in the United States.

Roland Thaxter, On the Myxobacteriaceae, a new order of Schizomycetes.

Benjamin Minge Duggar, Variability in the Spores of Uredo Polypodii.

Bradley Moore Davis, Euglenopsis: a new Alga-like Organism.

Herbert Maule Richards, Notes on Cultures of Exobasidium Andromedae and of Exobasidium Vaccinii.

And so forth. All show descriptive skills, detailed work on histology, thorough observations, and all are well illustrated (this in itself would be worthy of study). Science had moved west.

I do intend to end with a generalization, which is that the nature of research work which was most critical to ongoing advancement of a science was possible in North America only after a university scientific community developed, that it was a concern for ideas which most likely led to discovery rather than dedication to description. We in the present day must ask to what extent we are still working in the 19th century and we must come to grips with how we plan to systematize, classify and apply ideas in systematic, taxonomic studies. I have always been surprised by the lack of evolutionists among the mycologists. Are we still only describing and not analyzing?

I began with MacLeish and I feel I should end by quoting him: "The dead are excellent hosts: they have no objections."

ACKNOWLEDGEMENTS AND A NOTE ON SOURCES

I give below the sources which I have used for my primary information. I have not acted each piece of information separately. Like the taxonomists of the last century (and of the present day to a large extent) I have expressed opinion in this paper. I take full responsibility for the opinion; quotations and factual material may be traced in the published articles which follow. After having worked for nearly twelve years in the Farlow Library and Herbarium, in the course of which time I have read most of the letters and documents relating to Farlow, Thaxter, their students and associates, it is more than likely that information has crept in from my mental notes and is not derived from one of the publications listed below. If such proves to be the case I shall try to reconstruct as best I can upon demand.

The correspondence cited in this paper is obtained from: Harris, H.F. 1945. The correspondence of William G. Farlow during his student days at Strasbourg. Farlowia 2: 9-37.

Biographical information is taken primarily from: Linder, D.H. 1945. In honor of William Gilson Farlow. Farlowia 2: 1-7.

General historical information is derived from: Ainsworth, G.C. 1976. Introduction to the History of Mycology. Cambridge Univ. Press, Cambridge, 359 p.

The address of 1887, entitled The Task of American Botanists, to which reference is made was delivered before the American Society of Naturalists, Philadelphia, Dec. 29, 1886 and later published in the Popular Science Monthly 37: 305-314, 1887.

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NYSTATIN — A WONDER DRUG

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SUMMARY

Nystatin, the first antifungal antibiotic for use in human disease, was developed by microbiologist Elizabeth Hazen and organic chemist Rachel Brown at the Division of Laboratories and Research of the New York State Department of Health. Dr. Hazen surveyed soil microorganisms for antifungal substances in the period after World War II. An isolate of *Streptomyces noursei* was selected and cultured in New York City then sent to Dr. Brown in Albany where the extracts were prepared and returned to New York where they were tested. Nystatin, a name which was derived from N.Y. State, was commercially introduced in 1954 by the Squibb Company. The patent rights were assigned to a nonprofit organization. Thirteen million dollars of the royalties were used to support scientific activities in medical mycology between 1957 and 1978.

(Summary prepared by Symposium editors)

This is a story of two pioneer women scientists and of their selfless dedication. It is the story of a wonder drug, the first antifungal antibiotic effective and safe for use in human disease, and of 13 million dollars in royalties plowed back into investigative science. It is also, in part, the story of an early medical mycology laboratory in a pioneering state health department laboratory.

The two women were not only pioneers as professional women in a man's world, but also models of the dedicated, objective, unselfish scientist. Both began their lives in modest circumstances. Elizabeth Hazen, orphaned at an early age, was raised by relatives in rural Lula, Mississippi. Rachel Brown was raised by her mother in Springfield, Massachusetts. Their respective paths led them to New York State and to the Division of Laboratories and Research, where they blended into a persistent and productive team. Each had many outstanding achievements in her respective field, but most notable was their joint discovery and development of nystatin, with ensuing events, which I shall here relate.

Elizabeth Lee Hazen was born on August 24, 1885 to a farming couple in Lula. She attended an ungraded public school in Coahoma County, Mississippi and then completed high school and college in 5 years, graduating from the State College for Women (now Mississippi University for Women) in Columbus. She became a high school science teacher in Jackson, Mississippi, took summer courses in physics and biology at the University of Virginia and the University of Tennessee, and worked for a while as a laboratory technician, including a year's service in U.S. Army diagnostic laboratories in World War I. In 1916 she came to New York City and Columbia University to study bacteriology, acquiring an M.S. the following year. In 1926 she obtained her Ph.D. in Microbiology at Columbia, an institution which had granted only two Ph.D.'s to women in the medical sciences before 1920.

For the next 5 years Dr. Hazen was an instructor at the College of Physicians and Surgeons. When she joined the Division of Laboratories and Research, in 1931, her major responsibilities were in bacterial diagnosis. She investigated sources of anthrax and tularemia and was the first person in North America to identify and incriminate Clostridium botulinum, Type E, in deaths attributed to imported canned seafood. She studied with pioneer mycologist Rhoda Benham at Columbia and founded one of the earliest medical mycology diagnostic laboratories in the country, at the New York City Branch Laboratory of the State Health Department in 1944. She accompanied this laboratory upon its transfer to Albany in 1954. Her mycological research interests included investigation of very early histoplasmosis outbreaks in New York State (the earliest recorded epidemic of this disease, by the way, occurred in New York State at Plattsburgh in 1938); and studies on Actinomyces israelii and Microsporum audouinii. She was the senior author of one of the earliest handbooks in medical mycology, "Laboratory Identification of Pathogenic Fungi Simplified", first published in 1955 and currently in its 3rd edition, which I have had the privilege of coauthoring.

Dr. Hazen was a modest person, but not unassertive. To quote Steve Bacon of the Research Corporation (of which, more later), "always a retiring person who shunned publicity, Dr. Hazen avoided reporters and photographers, and delegated to others the task of reading her scientific papers". However, she knew and spoke her own mind. When the discovery of nystatin was announced before a meeting of the National Academy of Sciences in Syracuse, she reportedly seized a copy of the paper from the Science Editor of the New York Times, lecturing him sternly on the dangers of prematurely reporting the possible health benefits of the drug. She was known to scold subway riders in New York City for spitting; she berated a taxicab driver for taking her the long way home -- and was almost put out of the cab --; and she was observed to send her toast back 7 times during one breakfast meal. Dr. Hazen died in Seattle on June 24, 1975 at the age of 89.

Rachel Fuller Brown was born in Springfield, Massachusetts in 1898. She received a B.A. degree in chemistry and history from Mount Holyoke College in 1920 and the following year an M.S. degree in organic chemistry from the University of Chicago. She taught for several years and then, in 1926, joined the Division of Laboratories and Research of the State Health Department as a chemist and biochemist. While working here she received her Ph.D. degree from the University of Chicago in organic chemistry and bacteriology in 1933. Early in her career at the Division she isolated and identified polysaccharide antigens ("soluble specific substance") of numerous types and subtypes of pneumococci, which were used for production and standardization of antisera, at that time the standard treatment for infection with this bacterium, and for human immunization trials. These investigations have taken on renewed importance in recent years in view of the licensing and widespread use of a polyvalent pneumococcal vaccine and, in fact, some of the antigens prepared by Dr. Brown in those early years are still being used by today's investigators. A seminar by Dr. Gerald Schiffman entitled "Immune Response in Humans to Pneumococcal Polysaccharide Vaccine" had long been scheduled, but by coincidence took place in Albany on January 15, 1980, the day after Dr. Brown's death. Dr. Brown also did important work in syphilis serology, where she developed quantitative macro- and micro-precipitin tests with purified cardiolipin (isolated by her colleague, Dr. Mary Pangborn) in comparison with crude tissue extract. She was also active in community work, and became the first female member of the Vestry of St. Peter's Episcopal Church here in Albany. She died in Albany on January 14, 1980 at the age of 81.

Dr. Hazen and Dr. Brown were thus opposites in many ways. To quote from the book "Fungus Fighters", a biography of these two women, "Thus the collaboration began: Hazen the microbiologist -- slight, peppery, impatient, intensively active, and infinitely resourceful; Brown, the organic chemist -- sturdier and a few inches taller, solidly dependable, seemingly imperturbable, and quietly powerful when necessary. It was an odd combination, but one that worked."

Among the many honors accorded these two women were the Squibb Award in Chemotherapy, 1955; the Distinguished Service Award of the New York State Department of Health, 1968; honorary degrees of Doctor of Science at the commencement exercises of Hobart and William Smith College at Geneva, New York, 1969; and the Rhoda Benham Award of the Medical Mycological Society of the Americas in 1972. When they received the Chemical Pioneer Award of the American Institute of Chemists in 1975, they became the first women scientists ever selected for this honor. Furthermore, the Institute changed its bylaws in order to make an award to Dr. Hazen, a nonchemist. Both women served on the Brown-Hazen Awards Committee of the Research Corporation, administering the nystatin funds. They also initiated the Brown-Hazen Lectureship at the Division, which brought in many distinguished scientists.

After World War II, in the beginning of the antibiotic era, some of the state laboratory personnel became involved in examining soil microorganisms for antibiotics (this might be called a micro-foray). With the establishment of the Mycology Laboratory and growth of the field of medical mycology, Dr. Gilbert Dalldorf encouraged Dr. Hazen to search for antifungal substances (it became apparent later that many of the antibacterials contributed to a need for antifungals!). As Dr. Brown explained it in a tribute to Dr. Hazen on October 3, 1975, at a meeting of the Medical Mycology Society of New York, "In the beginning, as Dr. Dalldorf has told you, she was working at the Branch Laboratory in New York as a mycologist when I joined her as a chemist at the main laboratories in Albany. She had not yet selected a particular streptomycete upon which to concentrate but she soon chose Streptomyces noursei, her own isolate (from Virginia), as the most promising for antibiotic production."

"This is how the work progressed. She grew the cultures, shipped them to Albany where I prepared extracts and other fractions and sent samples of each to New York to be tested by her for antifungal activities. When the test results came back, I would determine how to proceed with the purification. All this merry-go-round occurred without a hitch. Of course there were many memoranda and occasional conferences in Albany or New York."

The original and still best-known use of nystatin (the name comes from N.Y. State) is, of course, in the treatment of mucosal and cutaneous candidiasis, including such forms as chronic mucocutaneous candidiasis and vaginitis. Its many other applications include widespread use in tissue culture to prevent mold contamination. It is also used in the microbiology laboratory as a genetic marker. In food industries, nystatin has a role in treatment of bananas before shipment, prevention of fatal moniliasis in turkeys, and as a food additive for livestock. Some of you may remember the great Florence flood of about 20 years ago, in which many priceless art objects were damaged or destroyed. You may wonder what nystatin had to do with this, but it had great success in removing the widespread mildew without injuring the paintings. Another role for nystatin in which you may be particularly interested is in the treatment of Dutch elm disease. In her original report Dr. Hazen had listed Ceratocystis ulmi as a "non-pathogen" sensitive to nystatin. It was only a few years ago that Boston area tree specialists reported having considerable success in saving elms that were not too severely infected, by direct injection of the antibiotic. Certainly another beneficial aspect of this type of treatment is the obviation of the environmental pollution which often follows spraying.

Nystatin was introduced commercially in 1954. Brown and Hazen assigned the patent rights to a nonprofit organization, the Research Corporation, which licensed its manufacture to the Squibb Company. In assigning rights of the discovery to the Foundation, Dr. Hazen and Dr. Brown specified that half of any royalty income was to go into a special fund, later named the Brown-Hazen fund, for grants in those areas of the biological sciences of interest to the inventors. The remainder was to be made available for other Research Corporation grants programs, primarily in the physical sciences. The fund became operative in 1957 as sufficient royalties accumulated, and the last disbursements were made with the expiration of the patent in 1976. Sales of nystatin generated 13 million dollars in royalties, all of which was used to support scientific activities, particularly research and training of young investigators and innovative projects. These included financial support for the mycology laboratories at the College of Physicians and Surgeons at Columbia University. The Brown-Hazen fund was for many years the single most important source of support nationally for work in medical mycology, and during the last 2 years of its existence was devoted exclusively to this purpose. Through training grants, it helped train a new generation of researchers and clinicians in this neglected field. Finally, it established the Rachel Brown fellowship-scholarship fund for women in the physical or biological sciences at Mount Holyoke College, the Elizabeth Hazen fund at the Mississippi University for Women, and the Dalldorf Postdoctoral Fellowship in Medical Mycology, which is administered by the Infectious Diseases Society of America. This fellowship, awarded annually since 1977, is of two-years' duration for each fellow, with a stipend of $22,000 annually plus $600 per dependent and $5,000 to the host laboratory.

The Brown-Hazen funds established and supported a prestigious lectureship award series at the Division of Laboratories and Research from 1958 to 1978, when the funds ran out. In 1982 the Division, now the Wadsworth Center for Laboratories and Research, took over the responsibility of supporting this series, the Brown-Hazen award lecture now being held at the Cultural Education Center auditorium each spring. So, the benefits of this extraordinary partnership continue to accrue in medicine, veterinary medicine, cytopathology, art restitution and good science.

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NOTES ON DISTRIBUTION OF *AMANITA ALBOCREATA*

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SUMMARY

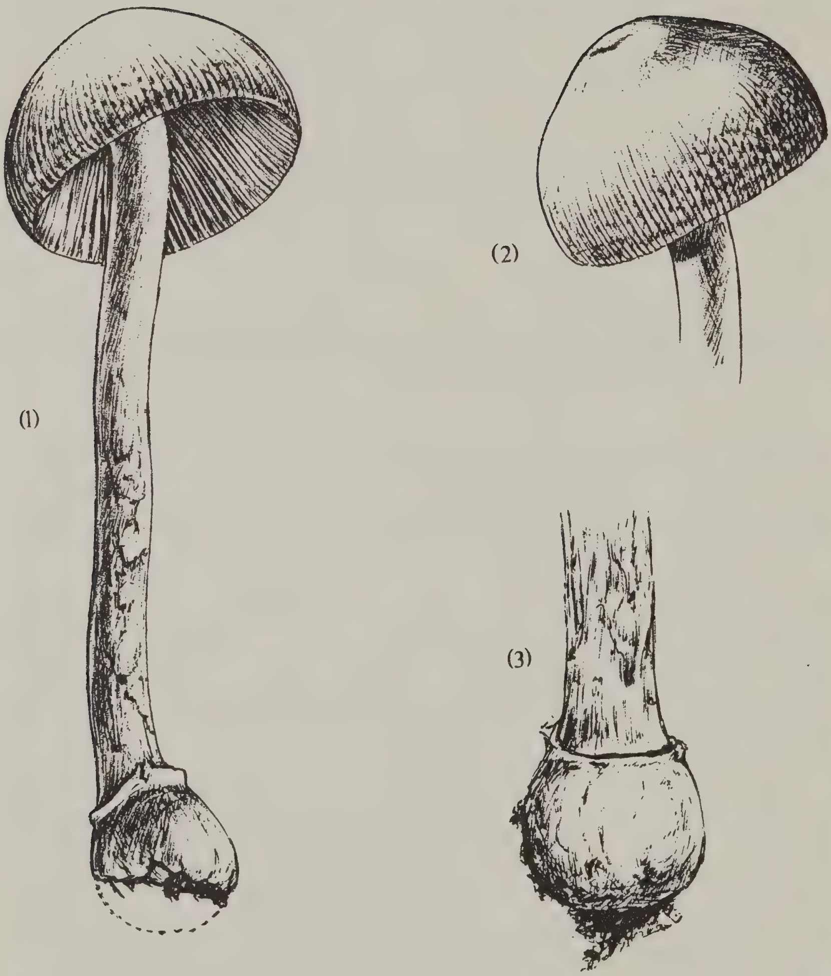
Recent collections of *Amanita albocreata* (Atkinson) Gilbert are the first reported outside of southwestern New York state. We delineate a distribution extending from northwestern New Jersey to central Maine.

This is one of a series of planned papers giving information on contemporary collections of *Amanita* taxa --- taxa that have not been, or have rarely been, collected and recorded in the literature since their original descriptions. We think it important to verify taxonomic characters by contemporary observation and to add details of taxonomy, range, and ecology where it is possible.

Amanita albocreata (Fig. 1-3) was originally described as *Amanitopsis albocreata* by G. F. Atkinson (1902) from the vicinity of Cayuga Lake and other sites in western New York state. Since that date, additional collections have not been reported in the literature. L. J. Tanghe has recognized this species in the vicinity of Rochester, New York and supplied us with color transparencies of a white capped collection dated "8/16/41." We know of no other collections of *A. albocreata* predating those described below.

Two collections of an *Amanita* in section *Amanita* made at the 1983 Northeast Mycological Foray and a third made recently in northwestern New Jersey conform closely to the characteristics expressed by the type of *Amanita albocreata* and to other collections in CUP* which were diagnosed by Atkinson and described by Jenkins (1977). In particular, we note the viscid, white pileus with yellowish disk and tuberculate-striate margin; small to medium size; slender habit; white exannulate stipe; cothurnate, white, globose to subglobose to broadly ellipsoid bulb; and average spore length/breadth (Based on 66 spores from 3 specimens) = 1.12. We note that there appears to be little variation in the per specimen average of this ratio in *A. albocreata*. Spores from the type exhibited an average length/breadth ratio of 1.08, and the largest average for any of the three collections cited here was 1.14. The average length/breadth of all spores measured from CUP collections was 1.10 (Jenkins, 1977).

* CUP - Herbarium, Department of Plant Pathology, Cornell University.



Figs. 1-3 *Amanita albocreata*. 1 & 2. 8-12-83-D [x1.1] from a color transparency of Tulloss. 3. Bulb [x1.5] from color transparency provided by S. S. Ristich, Cumberland Center, Cumberland County, Maine, July, 1984.

It is the view of Dr. C. Bas, Rijksherbarium, Leiden, The Netherlands (private correspondence) that per specimen ranges of average spore length, breadth, and length/breadth ratio are taxonomically useful in *Amanita*. Spores from our three collections, measured in Melzer's Reagent, exhibited these ranges: average length = 8.1-9.0 μm, mean 8.6 μm; average breadth = 7.1-8.1 μm, mean 7.7 μm; average length/breadth = 1.10-1.14, mean 1.12.

An L-tyrosine spot test was positive for tyrosinase (New Jersey collection) (Marr, 1979).

No data concerning vascular plants adjoining the Maine collecting sites were provided by the collectors. The New Jersey collection was made under *Tsuga canadensis* (L.) Carr. and *Quercus rubra* L. with *Betula lutea* Michx. and *Acer* sp. nearby.

Collections examined: MAINE, Penobscot County, Old Town: J. Hurley 8-12-83-D *(RET), NEMF participant 8-12-83-F *(DTJ); NEW JERSEY, Sussex County, Stokes State Forest: M. A. King, D. C. & R. E. Tulloss 7-7-95-A (RET).

ACKNOWLEDGEMENTS

We would like to thank Mr. Neal Macdonald, Princeton, New Jersey for preparing the illustrations. Our thanks are also extended to Dr. Richard Baird for reviewing this article.

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* RET - Herbarium of Rodham E. Tulloss.
DTJ - Herbarium of David T. Jenkins

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PROVISIONAL KEYS TO XYLARIA SPECIES IN CONTINENTAL UNITED STATES

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ABSTRACT

Dichotomous keys to Xylaria species in continental United States are presented. A reference containing a detailed description and, in most cases, an illustration is given for each species.

Xylaria Hill ex Schrank is a difficult genus for several reasons. First, stromata of a given species often vary greatly in color, size, and, sometimes, in general shape. These variations are associated with stages of development (immature, mature, senescent), locality, and probably inherent variability. Second, many species of Xylaria have cosmopolitan distributions. Most of them have been described more than once from different localities and, often, in different stages of maturity. It is thus often difficult to determine the correct name for a given taxon. Many taxa collected in USA were originally sent to Europe for identification or foreign literature was employed to make identifications. In several instances, what appear to be exclusively North American species have been equated with European species. In other instances, taxa that now seem identical with European species have been considered as unique. Likewise, there are problems in comparing USA taxa with tropical taxa. In any case, taxonomic studies of Xylaria from any continent, other land mass, or artificial land unit must take into account the taxa from other -- often widely separated -- regions. Cultural and anamorphic studies are contributing to our overall concepts of Xylaria taxonomy, but it will be many years before the data are complete. In the meantime, the working mycologist and plant pathologist have immediate needs to identify *Xylaria* taxa. The following keys are presented as a temporary aid for identification. Future research will result in changes of some names.

The keys are more or less artificial and are based largely on mature teleomorphic stromata. Separate keys are given to species ordinarily found on leaves, petioles, herbaceous stems, or dung; to species on seeds or fruits; to species on grasses; and to species on wood or soil. Some species seem highly host specific and, in these cases, the host(s) is listed. Species in the first three keys can be separated on ascospore characters, stromatal morphology, and, in some cases, specific hosts. Species on wood or soil are most numerous and they are initially separated on the general diameter ranges of stromata. It is to be understood, however, that such a separation is not absolute for some species. For example, *X. cornu-damae* and *X. hypoxylon* are keyed out as slender species, but robust specimens are sometimes encountered. The more consistently robust species on wood or soil are initially separated on general characters of the stromatal surface. However, these characters are variable and, occasionally, species cited as essentially smooth show fairly rugose stromata. Species are ultimately keyed out on ascospore and other stromatal characters. Figures 1-10 depict some of the characters used in the keys.

In addition to the keys, species are listed by obvious gross morphological characteristics. These lists should be consulted along with the keys in making identifications.

A reference is given for each species. References were chosen, in most cases, because they contain descriptions and illustrations applicable to USA material. In a few cases, there is no really satisfactory reference; the best (or only) available reference is given. In a few cases ascospore dimensions in the keys are not in complete accord with those in cited references. I have cited ranges for USA material actually seen by me. For example, tropical specimens of *X. allantoidea* have somewhat larger ascospores than specimens I have encountered in the USA.

Some species in the keys have been collected on very few occasions; others seem common. Rare species are marked as "R." Rough data on geographical distribution can be found for some of the species in cited references. Such data are not available for most of them.

Users of these keys will notice that some widely used names are not included, e.g., *X. digitata* (L.: Fr.) Grev. and *X. corniformis* (Fr.) Fr. In the case of the former species, undoubted specimens from USA have not been seen by me (9). In the case of the latter, the application of the name is in doubt (8,10). These and other problems are discussed in cited literature.

The species included in the keys undoubtedly do not represent all of the species of Xylaria in continental USA. Parts of the country -- particularly the deep south, southwest, and midwest -- have not been adequately explored for Xylaria and its kin. It thus would not be surprising for users of the key to encounter taxa new to science or taxa not previously recorded from continental USA.

ON FALLEN LEAVES, PETIOLES, HERBACEOUS STEMS, OR DUNG

1. Ascospores brown, 10-12 X 5-6 μm, with straight, spore-length germ slit. Fertile part subglobose, 1-2 mm diam. On fallen leaves of Bursera, etc. - - - - - - - - - - - - - - - - - - Xylaria aristata Mont.(3)

1. Ascospores brown, averaging shorter or longer. Fertile part of stroma consisting of scattered naked (superficial) perithecia - - - - - - - - - - - 2

    2. Ascospores 8.5-10.5 X 3-4.5 μm, with straight, spore-length germ slit. Perithecia 0.2-0.5 mm diam, scattered on stromatal axis ca. 1 cm long X 0.1 mm wide. On Lepus dung (R) - - - - - - - - - - - Xylaria cf. inaequalis Berk. & Curt.(3)

    2. Ascospores 13-18 X 4-7 μm, with straight, spore-length germ slit. Perithecia ca. 0.5 mm diam, scattered or clustered at intervals on stromatal axis up to 10 cm long X 0.1-0.8 mm diam. On various leaves, petioles, and herbaceous stems - - - - - - - - - - - - - - - - - Xylaria filiformis (Alb. & Schw.: Fr.) Fr.(4)

ON SEEDS OR FRUITS

1. Ascospores yellowish, 11-15(-17) X 3-5(-6) μm, without obvious germ slit. On fruits of Magnolia spp.- - - - - - - - Xylaria magnoliae J. D. Rogers(*7*)

1. Ascospores brown, with obvious germ slits of various morphologies. On other hosts. - - - - - - - - - - - 2

    2. Ascospores 10-12(-13.5) X 4.5-6 μm, with straight, spore-length germ slit. On fruits of Crataegus spp. and Carya spp. - Xylaria oxyacanthae Tul.(*12*)

    2. Ascospores averaging longer. On other hosts.- 3

3. Ascospores 10-15(-16) X 4-6 μm, with long, spiralling germ slit. On fruits of Liquidambar styraciflua L. and seeds of Prunus persica Batsch - - - - - - - - Xylaria persicaria (Schw.: Fr.) Berk & Curt.(*7*)

3. Ascospores 10-16 X 4-5 μm, with straight, spore-length germ slit. On fruits of Fagus grandifolia Ehrh. - - - - - - - Xylaria carpophila (Pers.) Fr.(*7*)

ON GRASSES

1. Ascospores brown, 15-18 X 8-10 μm, probably with long germ slit. Fertile part of stroma often branched near apex and flattened. On roots of Poa pratensis L. (R) - Xylaria multipartita Miller & Nielsen(*5*)

1. Ascospores brown, averaging smaller. Morphology of fertile part of stromata not as above- - - - - - - 2

2. Ascospores 11-13 X 4-6 µm, with straight, spore-length germ slit. Fertile part of stroma more or less flat-topped. On buried culms of Spatina patens (Ait.) Muhl. (R)- - - - - - - - - - - - - - - - Xylaria psamathos Boise(*1*)

2. Ascospores 10-12 X 5-5.5 µm, with straight, spore-length germ slit. Fertile part of stroma cylindrical with long, acute, sterile apex. On grass roots (R) - Xylaria graminicola Gerard(*4*)

ON WOOD AND SOIL

1. Stromata usually exceeding 5 mm in diameter- - - - 2

1. Stromata usually not exceeding 5 mm in diameter- -12

2. Stromatal surface essentially smooth (plane) except for large wrinkles and ostioles. Surface cracking is usually inconspicuous- - - - - - - - - - - - - - - 3

2. Stromatal surface roughened from small wrinkles, warts, perithecial contours, deep cracking, or combinations of these features - - - - - - - - - - - - - - - - - - 6

3. Ascospores brown, (7-)8-10.5(-13) X (3.5-)4-5(-6) µm, usually without obvious germ slit. Stromata copper-colored to dark brown - Xylaria cubensis (Mont.) Fr.(*10*)

3. Ascospores brown, averaging longer, usually with conspicuous germ slit. Stromatal colors various.- -4

4. Ascospores (8.5-)10-12 X (3-)3.5-4.5 µm, with straight germ slit usually less than spore-length. Stromata dull brown to blackish brown (R)- _Xylaria allantoidea_ (Berk.) Fr.(*10*)

4. Ascospores usually at least 13 µm long- - - - 5

5. Ascospores 14-18 X 5.5-7.5 µm, with straight germ slit usually somewhat less than spore-length. Stromata often at first whitish, then becoming blackish brown; in nature surface usually smooth, but often becoming rugose on drying- _Xylaria poitei_ (Lev.) Fr.(*10*)

5. Ascospores (12-)13-17.5(-19) X 4.5-6 µm, with straight, spore-length germ slit. Stromata initially whitish, becoming brown, and finally dull black. Surface usually smooth. Often associated with _Malus sylvestris_ (L.) Mill.- - - - - _Xylaria mali_ Fromme(*9*)

6. Ascospores brown, usually no longer than 12 µm - 7

6. Ascospores brown, usually longer than 12 µm - 8

7. Ascospores (8-)9-11(-12) X 4.5-5.5(-6) µm, with straight, spore-length germ slits. Stromata brown to blackish with yellowish interior; usually with abrupt, acute sterile apices- - - - - - - - - - - - - - - - - - _Xylaria bulbosa_ (Pers.) Berk & Br.(*8*)

7. Ascospores (8-)9-10(-11) X (3.5-)4.5-6 µm, with straight, spore-length slit. Stromata brown to black, usually with small or extensive areas of

white scales, with white interior; usually with broadly rounded fertile apices. Related taxa without persistent white scales have been called X. feejeensis (Berk.) Fr. and X. castorea Berk.- Xylaria curta Fr.(*8*)

8. Ascospores usually no longer than 19 μm - - - 9

8. Ascospores usually longer than 19 μm - - - - 10

9. Ascospores 14.5-17.5(-19) X 6-8 μm, with short, oblique germ slit. Stromata brown to brownish black; usually with abrupt, acute sterile apices - - - - - - - - - - - - - - Xylaria acuta Peck(*9*)

9. Ascospores (11-)13-15(-17) X (5-)6(-7) μm, with germ slit usually spiralling around ascospore for its full length, so that a portion is always visible when ascospore rotates. Stromata brownish to blackish; usually with broadly rounded fertile apices - Xylaria longipes Nits.(*8*)

10. Ascospores 20-23 X 7 μm, often with walls thickened at apices, with straight germ slit at least 2/3 spore-length. Stromata dull black (R) - - - - - - - Xylaria grandis Peck(*11*)

10. Ascospores 20-28 μm long, with straight or oblique germ slit 1/2-2/3 spore-length. Stromata dull brown to blackish; usually with rounded fertile apices- - - - - - - - - 11

11. Ascospores with straight to slightly oblique germ slit. Most perithecia with large propor-

tion of ascospores with straight slits - - - - - - - - - - - - - Xylaria polymorpha (Pers.: Fr.) Grev.(*11*)

11. Ascospores with oblique, curving or spiralling germ slits. Most perithecia with small proportion of, or no, ascospores with straight slits (R)- - - - - - - - - - - Xylaria schweinitzii Berk. & Curt.(*11*)

12. Ascospores brown, usually longer than 16 μm - 13

12. Ascospores brown, usually no longer than 16 μm - 15

13. Ascospores 17.5-22 X 7-9 μm, with a persistent cellular appendage on one end and a fugacious non-cellular appendage on the other, with straight germ slit somewhat less than spore-length. Fertile part of stroma 3-6 mm long consisting of a cluster of naked (superficial), strongly papillate perithecia - - - - Xylaria tentaculata Berk. & Br.(*2*)

13. Ascospores mostly as above, but appendage (when present) an inconspicuous cell on one end of spore. Fertile parts of stromata with inconspicuous (immersed) perithecia- - - - - - - - - - 14

14. Ascospores (16-)17.5-22(-25) X 4.5-6(-6.5) μm, with short, straight germ slit. Stromata variable in shape, at first appearing white-washed, becoming black, but usually retaining traces of white - Xylaria cornu-damae (Schw.) Fr.(*9*)

14. Ascospores 19-23.5 X 7-9 μm, sometimes with an inconspicuous cellular appendage on one

end, with undulating spore-length germ slit. Stromata conic, roughened by conspicuous tan peeling layer (R) - *Xylaria* cf. *apiculata* Cooke(3)

15. Ascospores usually no shorter than 12 µm or longer than 16 µm - - - - - - - - - - - - - - - - - 16

15. Ascospores usually no longer than 12 µm - - - - - 17

    16. Ascospores 12-16 X 5-6.5 µm, with straight germ slit slightly less than spore-length. Stromata at first white, becoming black; often branched, flattened, with apices acute and sterile. Perithecia often naked (superficial) - *Xylaria hypoxylon* (L.: Fr.) Grev.(4)

    16. Ascospores (12-)14-15 X 4.5-6.5 µm, with straight germ slit less than spore-length. Stromata black with shredding grey to tan layer. Perithecia mostly immersed (inconspicuous).- - - - - - *Xylaria arbuscula* Sacc.(3)

17. Ascospores usually no longer than 9 µm- - - - - - 18

17. Ascospores mostly 9-12 µm - - - - - - - - - - - - - 19

    18. Ascospores 6-7 X 2-3 µm, with straight germ slit less than spore-length. Stromata greyish white with black ostioles - - - - - - - - - - - - - - - - *Xylaria* cf. *coccophora* Mont.(3)

    18. Ascospores 7-9 X 4-4.5 µm, with germ slit morphology unknown. Stromata light orange with black ostioles (R) - *Xylaria fulvella* Berk. & Curt.(3)

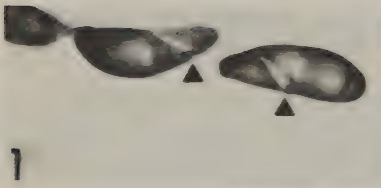
19. Ascospores 9-11 X 4.5-5 µm, with straight spore-length germ slit. Stromata at first white, becoming black at maturity, solitary to cespitose. Often called *X. hypoxylon* "small-spored form"- *Xylaria longiana* Rehm(*6*)

19. Ascospores (9-)10-12(-13) X 4.5-6 µm, with straight, spore-length germ slit. Stromata black with brown to dark brown, shredding outer layer; usually densely cespitose- *Xylaria multiplex* (Kunze) Fr.(*3*)

SPECIES LISTED BY OBVIOUS MORPHOLOGICAL CHARACTERISTICS

A. Stromata often over 5 cm high and 1 cm thick: *X. allantoidea*, *X. grandis*, *X. mali*, *X. poitei*, *X. polymorpha*, *X. schweinitzii*.

Figs. 1-10. Depiction of some characters employed in keys to *Xylaria*. 1. Ascospores of *X. persicaria* with long, spiralling germ slits. Portions of slits visible at arrows. 2 and 3. Ascospores of *X. poitei* and *X. mali*, respectively, with long, straight germ slits that are nearly spore-length. 4 and 5. Ascospores of *X. acuta* and *X. schweinitzii*, respectively, with oblique germ slits that are considerably less than spore-length. 6. Ascospore of *X. polymorpha* with straight germ slit that is considerably less than spore-length. 7. Naked or superficial perithecia of a *Xylaria* closely related to *X. filiformis*. Perithecia are attached to thin stromatal axis exposed at far right. 8. Naked or superficial perithecia of *X. hypoxylon*, their contours evident on stromatal surface. 9. Rough stromatal surface of *X. longipes*. Contributing to the stromatal relief are small wrinkles, fine cracks, papillate perithecial ostioles and warts. Perithecia are mostly immersed and inconspicuous. 10. Smooth or plane stromatal surface of *X. cubensis*. Surface is slightly roughened by small papillate ostioles and fine surface cracks. Perithecia completely immersed. Figs. 1-6 ca. X 1500. Figs. 7-10 ca. X 18.



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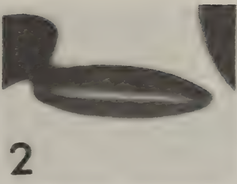

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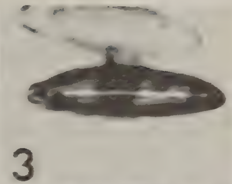

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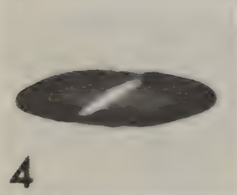

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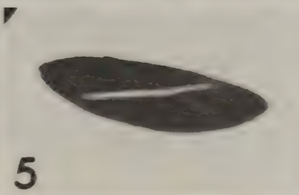

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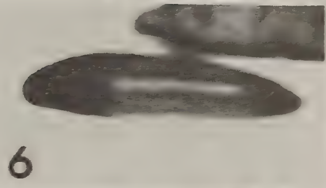

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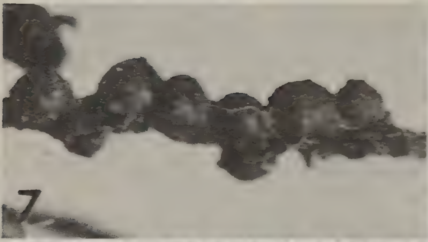

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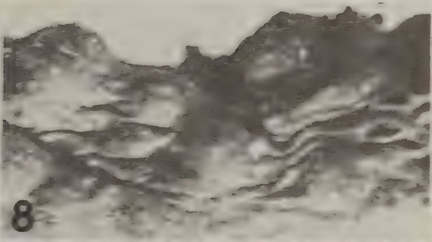

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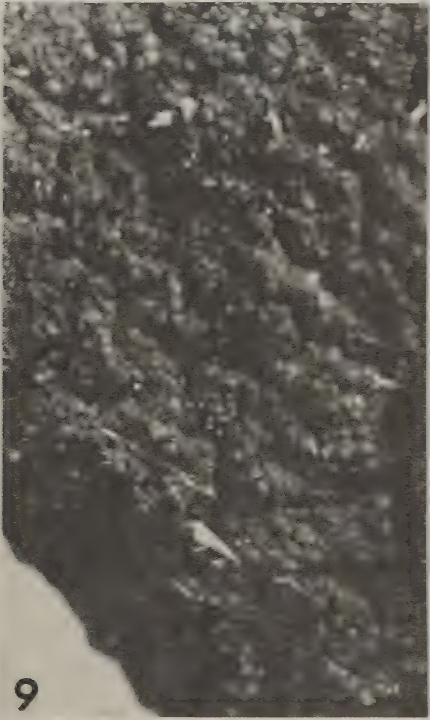

9

10

B. Stromata often highly flattened, especially at apices: *X. cornu-damae*, *X. hypoxylon*, *X. mali*, *X. multipartita*.

C. Stromata usually with rounded fertile (perithecial) apices: *X. allantoidea*, *X. cubensis*, *X. curta*, *X. grandis*, *X. longipes*, *X. poitei*, *X. polymorpha*, *X. schweinitzii*.

D. Stromata usually with acute or greatly attenuated, sterile (nonperithecial) apices: *X. acuta*, *X. apiculata*, *X. arbuscula*, *X. bulbosa*, *X. carpophila*, *X. coccophora*, *X. cornu-damae*, *X. filiformis*, *X. graminicola*, *X. hypoxylon*, *X. longiana*, *X. magnoliae*, *X. multiplex*, *X. oxyacanthae*, *X. persicaria*.

E. Stromata usually bearing perithecia with contours so evident as to appear naked: *X. filiformis*, *X. hypoxylon*, *X. inaequalis*, *X. tentaculata*.

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THE DIFFERENTIATION OF ENDOTHIA AND CRYPHONECTRIA SPECIES BY EXPOSURE TO SELECTED FUNGITOXICANTS

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SUMMARY

The sensitivities of representative species of Endothia and Cryphonectria to 21 fungitoxicants were compared to determine whether selective toxicities occur among taxa. Differential sensitivities were observed toward cycloheximide; with the exception of E. viridistroma, Endothia species were 100 times more sensitive than were species of Cryphonectria. Cycloheximide-amended media can be used to distinguish between isolates of E. gyrosa and C. parasitica. Such a large difference in response usually reflects genetic (and therefore physiological and structural) diversity and supports Barr's separation of the taxa. Little or no differential sensitivities were detected to the remaining fungitoxicants indicating that the organisms share many common metabolic pathways.

INTRODUCTION

The traditional description of the fungal genus Endothia Fr. (14) characterizes a group of organisms which is distributed throughout the world and includes several important plant pathogens. The taxonomy (12) and pathogenicity (18) of this genus have been reviewed. The most renown species is Endothia parasitica (Murr.) P. J. & H. W. And., the causal agent of chestnut blight; this organism is responsible for the elimination of the American chestnut, Castanea dentata Borkh., as a dominant species of the eastern hardwood forest. The destruction associated with E. parasitica is not typical of the genus; the remaining organisms are opportunistic pathogens or saprobes. One such example is E. gyrosa (Schw.) Fr., the causal agent of pin oak blight. This organism is a serious threat to drought-stricken pin oak, Quercus palustris Muenchh., and willow oak, Quercus phellos L., in the southeastern United States (1, 18). Another species of Endothia associated with a particular disease is Endothia eugeniae (Nutman & Roberts) Reid, which causes "acute die-back" of clove, *Syzygium aromaticum* (L.) Merr. & Perry (10). The remaining species have not been associated with any specific diseases and are presumably saprobic, although all of these organisms are potentially destructive when introduced into new areas with highly susceptible hosts. Rapid and accurate means of identification are necessary so that introduced species can be detected before epiphytotics develop.

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Barr's recent monograph on the Order Diaporthales (2) radically altered the taxonomic status of this group. The genus *Endothia* was reassigned from the Diaporthaceae (9) to the Gnomoniaceae; this change reflects a reinterpretation at the ordinal level since the Diaporthaceae ss. Müller and von Arx (9) is represented by the four families of the Diaporthales ss. Barr (2). The genus was also restricted to those species which produce allantoid, one-celled ascospores, and diatrypoid stromata composed of predominantly pseudoparenchymatous tissues. The species retained in *Endothia* were *E. gyrosa*, *E. singularis* (H. & B. Syd.) Shear & Stevens and *E. viridistroma* Wehmeyer. The remaining species were transferred to the genus *Cryphonectria* Sacc. of the Valsaceae on the basis of their ovoid to ellipsoid, two-celled ascospores, and valsoid stromata composed of predominantly prosenchymatous tissues. The new species designations are presented in Table 1. *Endothia eugeniae* and *E. coccolobii* Vizioli were not mentioned by Barr but should probably be reassigned to *Cryphonectria* because of their morphological characteristics. *Diaporthe cubensis* (Bruner), which causes a serious canker disease of eucalyptus, was transferred to *Cryphonectria* by Hodges (6); this organism is believed to be conspecific with *E. eugeniae* (7).

The simplest way to distinguish between *Endothia* and *Cryphonectria* is by the shape and septation of the ascospore. Field collections often lack the teleomorph, and perithecia have not been reported in agar culture; identification to the genus and species level, therefore, is frequently difficult. For this reason, chemotaxonomic characteristics were sought to separate the taxa. Differential sensitivities to antibiotics, fungitoxicants and other xenobiotic agents have been used to distinguish closely related fungi; this topic has been reviewed (4). Such variations in susceptibility reflect differences in metabolism and provide the taxonomist with phenotypic traits which can be used in the absence of morphological characteristics.

Differential sensitivities are most frequently expressed at the class or ordinal level: for example, benzimidazoles are usually active against Ascomycetes and Fungi Imperfecti, while oxathiins are usually toxic to Basidiomycetes (4). Variations in sensitivity to a particular fungitoxicant have been reported among genera and species. Isolates of *Fusarium solani* (Mart.) Appel & Wr. were separated from other species of *Fusarium* by their unusual dosage-response curve which was formed upon exposure to benomyl and thiabendazole (11). Diverse sensitivities to cycloheximide were used to partition the genus *Ceratocystis* into two distinct groups which corresponded with other physiological and anamorphic differences (5). *Rhizoctonia solani* Kuehn was distinguished from *R. zeae* Voorhees by its greater sensitivity toward benomyl, and different anastomosis groups of *R. solani* varied in their responses to carboxin, PCNB, chlorothalonil and triadimefon (8). Such studies show that selective toxicities to fungitoxicants have taxonomic value.

The objectives of this project were to determine whether differential sensitivities to a variety of compounds could be used to distinguish among species of *Endothia* and species of *Cryphonectria* and to determine whether Barr's classification system reflects differences in

Table 1. Isolate numbers, sources, dates of collection and hosts of *Endothia* and *Cryphonectria* species used in this study.

Species	Isolate Number[a]	Source of Collection	Collection Date	Host
Cryphonectria cubensis (Bruner) Hodges	H151	Wynaud, Calicut, India	11/82	*Eucalyptus grandis* Hill & Maid.
	H154	Uverito, Venezuela	1/82	*Eucalyptus grandis*
	H182 IMI268904	Jarrahdale, Australia	4/82	*Eucalyptus marginata* Donn & Sm.
Cryphonectria gyrosa (Berk. & Br.) Sacc. = *Endothia tropicalis* Shear & Stevens	E57	Auckland, New Zealand		*Elaeocarpus dentatus* Vahl.
	E70	Auckland, New Zealand		*Elaeocarpus dentatus*
Cryphonectria havanensis (Bruner) Barr = *Endothia havanensis* Bruner	E40 CBS505.63	Loandijli, Congo		*Eucalyptus saligna* Sm.
	E158	Tampa Bay, FL	3/82	*Eucalyptus camaldulensis* Dehn.
	E159	Tampa Bay, FL	3/82	*Eucalyptus camaldulensis*
	H183	Darling Range, Australia	4/81	*Eucalyptus marginata*
Cryphonectria macrospora (Kobayashi & Ito) Barr = *Endothia macrospora* Kobayashi & Ito	E54V	Kamakuro, Japan	12/71	*Castanopsis cuspidata* (Thunb.) Schottkg.
Cryphonectria nitschkei (Otth.) Barr = *Endothia japonica* Kobayashi & Ito	E53V	Nagano Japan	10/65	*Quercus mongolica* v. *grossesserrata* (Bl.) Rehd
	E59V		12/74	*Quercus mongolica* v. *grossesserrata*
Cryphonectria parasitica (Murr.) Barr = *Endothia parasitica* (Murr.) P.J. & H.W. And.	E24V	Tifton, GA	4/72	*Castanea mollissima* Blume
	E85V	Cherokee Nat. For., TN	4/76	*Castanea dentata* Borkh.
	E86V	Alum. Ridge, VA	4/76	*Castanea dentata*
	E87V	Floyd Co., VA	4/76	*Castanea dentata*
	E88V	Alaben, NY	6/76	*Castanea dentata*

Species	Isolate Number[a]	Source of Collection	Collection Date	Host
Cryphonectria parasitica (con't)	E89	Williamsburg, VA	7/63	*Quercus virginiana* Mill.
	E95V	Hampton, ME	8/76	*Castanea dentata*
	E96V	Camp Hill, PA	8/76	*Castanea dentata*
	E107	Augusta Co., VA	9/76	*Castanea dentata*
	E108	Blacksburg, VA	5/77	*Castanea mollissima*
	E137V	Boyce, VA	2/77	*Castanea mollissima*
	E153V	Blacksburg, VA	10/82	*Castanea dentata*
	E155V	Craig Co., VA	12/82	*Quercus velutina* Lam.
Cryphonectria radicalis (Schw. & Fr.) Barr = *Endothia radicalis* (Schw.) Ces. & DeNot.	E16 CBS202.54			*Castanea sativa* Mill.
	E42 CBS202.54			*Castanea sativa*
	E56	Auckland, New Zealand		*Fuchsia excortica* L.
	E64	Auckland, New Zealand		
	E67	Auckland, New Zealand		
	E76 CBS240.54			*Castanea sativa*
	E150	Skiti, Greece		*Castanea sativa*
	E152	Skiti, Greece		*Castanea sativa*
Endothia coccolobii Vizioli	E157V	Fort Lauderdale, FL	10/82	*Coccoloba uvifera* (L.) Jacq.
Endothia eugeniae (Nutman & Roberts) Reid & Booth	E138 IMI44845	Zanzibar, Tanzania	1951	*Syzygium aromaticum* (L.) Merr. & Perry
	E139 IMI56425a	Barns, Malaya	1954	*Syzygium aromaticum*
	H184	Itubara, Bahai, Brazil	12/83	*Syzygium aromaticum*
Endothia gyrosa (Schw.) Fr.	E18V	Hampton, VA	9/70	*Quercus palustris* Muenchh.
	E20V	Hampton, VA	9/70	*Quercus palustris*
	E30V	Eastern Shore, VA	11/72	*Quercus palustris*
	E37V	Alexandria, VA	8/73	*Quercus palustris*
	E38V	Alexandria, VA	9/73	*Acer saccharinum* L.
	E48	Auburn, AL	5/74	*Quercus palustris*
	E50V	Franklin Co., VA	7/74	*Quercus palustris*

Species	Isolate Number[a]	Source of Collection	Collection Date	Host
Endothia gyrosa (con't)	E51V	South Boston, VA	7/74	*Quercus marilandica* Muenchh.
	E72V CBS509.76	Surry Co., VA	10/75	*Quercus palustris*
	E73	Hampton, VA	10/75	*Quercus palustris*
	E74V CBS510.76	Norfolk, VA	12/75	*Quercus suber* L.
	E98V	Lynchburg, VA	10/76	*Quercus palustris*
	E145V	Charlestown, WV	2/80	*Fagus grandifolia* Ehrh.
	E154V	Arlington, VA	11/82	*Quercus palustris*
Endothia singularis (H. & B. Syd.) Shear & Stevens	E58V	Silver Mountain, CO		*Quercus gambelii* Nutt.
Endothia viridistroma Wehmeyer	E41 CBS202.36	Athens, GA		*Cercis canadensis* L.
	E82 CBS249.54	Athens GA		*Cercis canadensis*

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[a] All isolates maintained in the culture collection of Dr. R. J. Stipes, Department of Plant Pathology, Physiology and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, VA. Isolates designated "V" represent those with vouchered specimens. Isolate numbers beginning with "H" obtained from the culture collection of Dr. C. S. Hodges, USDA - Forest Service.

fungal metabolism.

MATERIALS AND METHODS

Cultures of *Endothia* and *Cryphonectria* species were stored at 4°C on 1 % glucose - 0.2 % yeast extract agar slants (19). Isolate numbers, sources, dates of collection and hosts are listed in Table 1.

Fungitoxicants were prepared as stock solutions on a w/v basis with the exception of liquid formulations, which were made as v/v solutions. The following solvent - fungitoxicant combinations were used: sterile distilled water - chlortetracycline; absolute ethanol - chloramphenicol, thiabendazole hypophosphite, Fungisol^{R}, MBC phosphate, benzimidazole, triadimefon, fosetyl-Al, o-phenylphenol, cycloheximide; acetone - chloroneb, iprodione, mancozeb, anilazine, chlorothalonil; methanol - nystatin; dimethyl sulfoxide - candicidin, amphotericin B; chloroform - PCNB; acetone: methylene chloride (1:1) - dicloran, vinclozolin. Common, trade and chemical names, chemical class, formulation and manufacturer are listed in Table 2. Stock solutions were added to the molten basal medium, Difco potato-dextrose agar (PDA), at 1 ml / liter medium. Nonamended control media contained 1 ml of the appropriate solvent / liter PDA. Final concentrations of the fungitoxicants varied with each test following preliminary screening with the concentrations 0.01, 0.1, 1, 10, and 100 µg/ml.

Approximately 20 ml of medium were dispensed into 85-mm-diameter Petri plates with 3 replicate plates / concentration / isolate tested. Individual plates were then inoculated along one edge with a 5-mm plug taken from the margin of 7 to 30-d-old isolates grown on nonamended PDA. Colonies were incubated for 8 d at 25 °C. The average colony radius was determined for each concentration of fungitoxicant and the control; the percent growth inhibition was then calculated for each concentration. Linear regression analysis, as performed by Statistical Analysis Systems (SAS), was used to establish the dosage-response curve and to estimate the ED$_{50}$ value of each species when differential sensitivities were found. Each fungitoxicant was initially screened with one to five isolates each of *C. parasitica* and *E. gyrosa*. Compounds to which differential sensitivities were detected were further tested with 10 - 12 isolates of these two species; the experiment was then repeated. Sensitivities of additional taxa were determined when extreme differences were found among isolates of *C. parasitica* and *E. gyrosa*.

RESULTS AND DISCUSSION

Isolates of *E. gyrosa* and *C. parasitica*, the two most common species of this complex in the eastern United States, were differentially sensitive to cycloheximide, an antifungal antibiotic. *Cryphonectria parasitica* was able to grow at concentrations which totally prevented the growth of *E. gyrosa*. This differential response is reflected in the dosage-response curves (Figures 1 and 2) and in the ED$_{50}$ values (Table 3) of 0.01 - 0.03 µg/ml and 1.0 - 2.0 µg/ml for *E. gyrosa* and *C. parasitica*, respectively. This represents a hundred-fold difference in sensitivity and probably reflects metabolic differences in the fungi. Similar results were obtained at 7 and 14 days; this indicates that the sensitivities of the fungi did not change with time and that the compound did not break down in the medium. Differential sensitivity to this compound was also observed when 0.5 % glucose - 0.1 % yeast extract agar (19) was used as the basal medium.

Table 2. Technical, trade and chemical names, chemical class, formulations and manufacturers of the fungitoxicants used in this study.

Technical name	Trade name	Chemical name or formula	Chemical class	Formulation	Manufacturer
cycloheximide	Actidione®	3-(2-(3,5-Dimethyl-2-oxocyclohexyl)-2-hydroxyethyl-glutarimide	antifungal antibiotic	technical 100%	Upjohn Co.
chlortetracycline HCl		7-Chloro-4-dimethylamino-1,4,4a,5,5a,6,11,12a-octahydro-3,6,10,12,12a-pentahydroxy-6-methyl-1,11-dioxo-2-naphthacenecarboxamide	antifungal antibiotic	technical 100%	U.S. Biochemical Corp.
nystatin		$C_{47}H_{75}NO_{17}$	polyene antibiotic	technical 100%	American Cyanamid
candicidin		$C_{63}H_{85}N_{21}O_{19}$ (tentative)	polyene antibiotic	technical 100%	Julius Schmid, Inc.
amphotericin B type I		$C_{47}H_{73}NO_{17}$	polyene antibiotic	technical 100%	Squibb & Sons
chloramphenicol	Chloromycetin®	D(-)-Threo-2,2-dichloro-N-(B-hydroxy-a-hydroxymethyl)-p-nitrophenyl-2-amino-1,3-propanediol	antifungal antibiotic	technical 100%	Parke-Davis
captan	Orthocide®	cis-N-((Trichloromethyl)thio)-4-cyclohexene-1,2-dicarboximide	dicarboximide	technical 100%	Chevron
iprodione	Rovral®	3(3,5-Dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidinecarboxamide	dicarboximide	50WP	Rhone-Poulenc Inc.

Technical name	Trade name	Chemical name or formula	Chemical class	Formulation	Manufacturer
vinclozolin	Ronilan®	3-(3,5-Dichlorophenyl)-5-ethenyl-5-methyl-2,4-oxazolidinedione	dicarboximide	50WP	BASF Wyandotte
PCNB	Terrachlor®	pentachloronitrobenzene	substituted aromatic	technical 100%	Olin Corp.
dicloran	Botran®	2,6-Dichloro-4-nitroanaline	substituted aromatic	75WP	Upjohn Co.
chlorothalonil	Daconil® 2787	tetrachloroisophthalonitrile	substituted aromatic	75 WP	Diamond Shamrock
chloroneb	Demosan®	1,4-Dichloro-2,5-dimethoxybenzene	subsituted aromatic	technical 90%	DuPont Corp.
O-phenyl phenol		ortho-phenyl phenol	substituted aromatic	technical 100%	Aldrich
benzimidazole		N,N'-Methenyl-o-phenylenediamine	benzimidazole	technical 100%	Eastman
thiabendazole hypophosphite	Arbotect® 20S	2-(4-Thiazolyl)benzimidazole, hypophosphite salt	benzimidazole	solution 26.6%	Merck & Co.
MBC phosphate	Lignasan® BLP	Methyl-2-benzimidazolecarbamate phosphate	benzimidazole	solution 0.7%	DuPont Corp.
	Fungisol®	2-(2-ethoxyethoxy)ethyl -2-benzimidazole carbamate (1.7%) + methyl-2-benzimidazole carbamate (0.3%)	benzimidazole	solution 2.0%	J.J. Mauget Co.

Technical name	Trade name	Chemical name or formula	Chemical class	Formulation	Manufacturer
mancozeb	Fore ®	manganese ethylene bisdithiocarbamate + zinc ion	dithiocarbamate	80WP	Rohm & Haas Co.
anilizine	Dyrene ®	4,6-Dichloro-N-(2-chlorophenyl)-1,3,5-triazin-2-amine	triazinamine	50WP	Mobay Chemical
triadimefon	Bayleton ®	1-(4-Chlorophenoxy)-3-3-dimethyl-(1H-1,2,4-trizol-1-yl)-1-butanone	triazole	50WP	Mobay Chemical
fosetyl-Al	Aliette ®	aluminum tris(-0-ethyl)phosphonate	phosphonate	80WP	Rhone-Poulenc Inc.

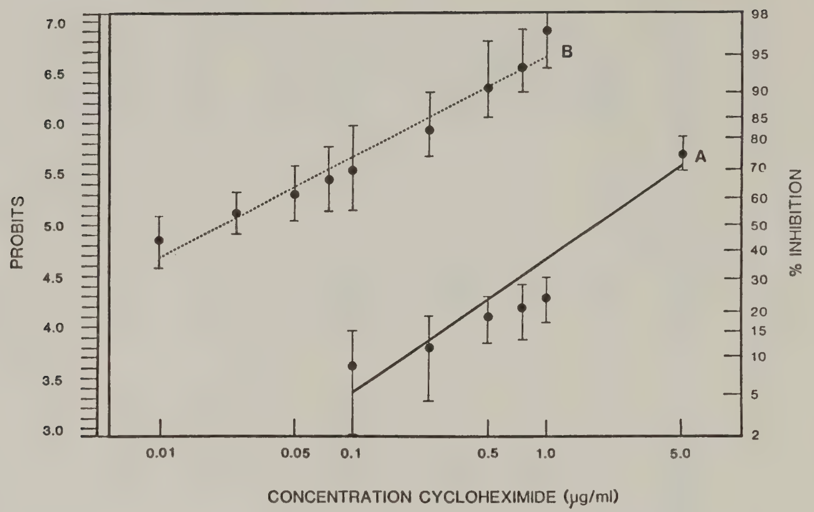

Figure 1. Dosage-response curve of Cryphonectria parasitica (A) and Endothia gyrosa (B) grown on cycloheximide-amended potato-dextrose agar at 25 °C for 7 d. Average of 11 isolates per species and three replicate plates per isolate. Vertical bars represent the standard deviation of the mean. Concentration plotted on a logarithmic scale.

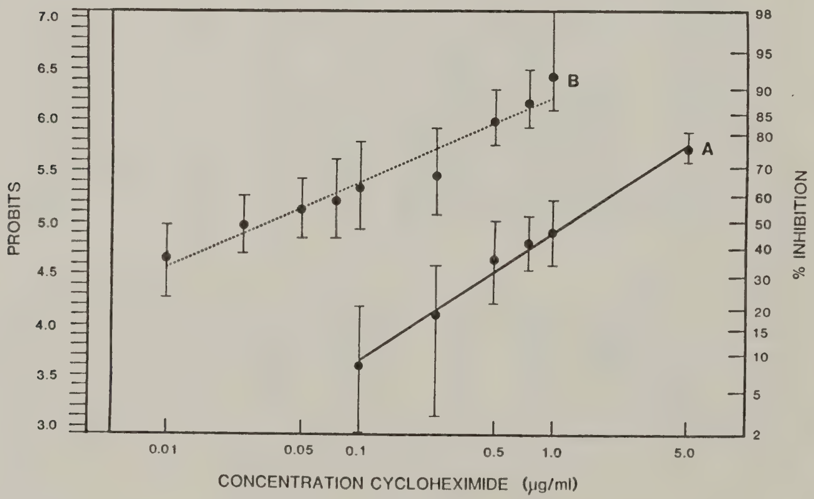

Figure 2. Dosage-response curve of Cryphonectria parasitica (A) and Endothia gyrosa (B) grown on cycloheximide-amended potato-dextrose agar at 25 °C for 14 d. Average of 11 isolates per species and three replicate plates per isolate. Vertical bars represent the standard deviation of the mean. Concentration plotted on a logarithmic scale.

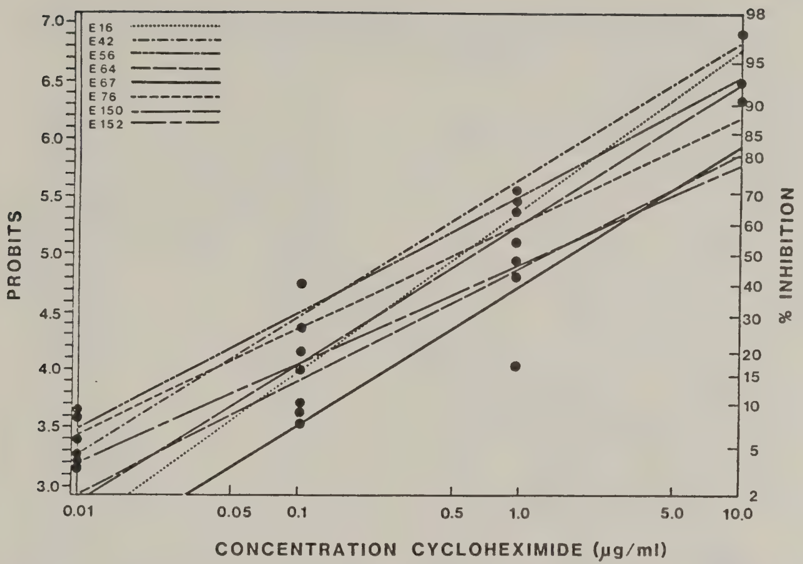

Figure 3. Dosage-response curve of eight isolates of Cryphonectria radicalis grown on cycloheximide-amended potato-dextrose agar at 25 °C for 7 d; average of three replicate plates per isolate. Concentration plotted on a logarithmic scale.

Cycloheximide altered pigment production in E. gyrosa. A reddish-purple pigment, which has been termed "perilla purple" (14) and "endothine red" (13), was produced in large quantities at cycloheximide concentrations below 1 μg/ml, while a brilliant yellow pigment was released into the medium at concentrations of 1 and 5 μg/ml despite a complete absence of visible mycelial growth. Isolates of C. parasitica did not display any change in pigment production, even at concentrations of 100 μg/ml.

A cycloheximide-amended medium could be used in a clinical situation to differentiate between E. gyrosa and C. parasitica. Both fungi produce red to orange-pigmented stromata and are difficult to differentiate in the anamorphic state. A cycloheximide concentration of 1 μg/ml in a basal medium would be ideal for this purpose; at this level the growth of E. gyrosa is totally inhibited, while that of C. parasitica is reduced by only 30 - 50%.

Cycloheximide sensitivity was also determined for 10 other species of Endothia and Cryphonectria. Dosage-response curves are presented in Figures 3 - 5, and ED_{50} values are listed in Table 3. The ED_{50} values were somewhat variable between the two experiments, and a limited number of isolates of each species was available for these tests, but some general trends were evident. Most species responded to cycloheximide as did C. parasitica, with ED_{50} values between 0.5 - 5.0 μg/ml. Several isolates were much more sensitive, however. An ED_{50} value of 0.1 μg/ml can be used to divide the species into two groups based on their response (Table 4). This division substantiates Barr's separation of Endothia from Cryphonectria with a few exceptions. Isolates of E. viridistroma were more resistant to cycloheximide than

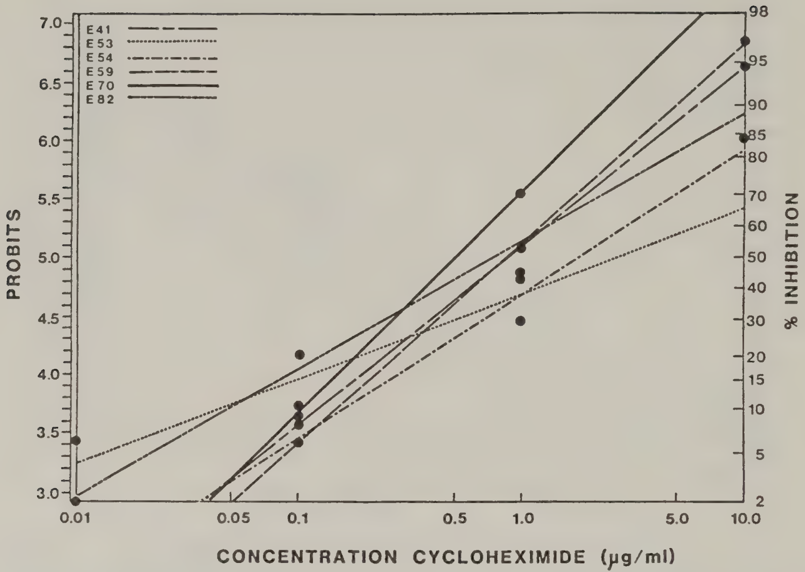

Figure 4. Dosage-response curve of Endothia viridistroma (E41, E82), Cryphonectria nitschkei (E53, E59), Cryphonectria macrospora (E54) and Cryphonectria gyrosa (E70) grown on cycloheximide-amended potato-dextrose agar at 25 °C for 7 d; average of three replicate plates per isolate. Concentration plotted on a logarithmic scale.

were the other species retained in Endothia. Endothia viridistroma is the only species which forms green stromata (20); its taxonomic position needs to be reevaluated in light of these findings. Two putative isolates of C. havanensis from Florida were also extremely sensitive to the compound (ED_{50} = 0.05 - 0.06 µg/ml). The identity of these organisms is not certain due to the absence of the teleomorph in the field collections; tentative identification was based on stromal size and isolation from eucalyptus. The remaining isolates of C. havanensis used in this study produced electrophoretic protein patterns similar to those of C. cubensis (Bruner) Hodges and E. eugeniae (Micales, unpublished), so their identity is suspect. The sensitivity of C. havanensis to cycloheximide must remain uncertain until cultures from fresh, vouchered specimens are obtained.

Isolates of E. eugeniae and C. cubensis produced similar dosage-response curves with the exception of C. cubensis isolate H182; this isolate was extremely sensitive to cycloheximide (ED_{50} = 0.01 µg/ml), while the remaining organisms were much more resistant (ED_{50} = 0.9 - 3.6 µg/ml). The colony morphology of this culture did not resemble those of the other members of this group, and the isolate produced atypical electrophoretic protein patterns (Micales, unpublished). This isolate was probably misidentified or contaminated in culture.

Abnormal pigment production was observed among these additional species and included increased levels of "perilla purple" (C. radicalis and E. singularis), and dark brown to black (C. nitschkei and C.

Table 3: ED$_{50}$ values of isolates of *Endothia* and *Cryphonectria* species for cycloheximide.

Species	Isolate	Test 1	Test 2	
		7 days	7 days	14 days
C. cubensis	H151	3.61	3.02	ND[a]
	H154	2.04	0.88	ND
	H182	ND	0.03	0.03
C. gyrosa	E57	2.72	ND	1.43
	E70	0.72	0.49	0.68
C. havanensis	E40	1.38	0.91	2.96
	E158	0.05	0.06	0.18
	E159	0.05	0.05	0.12
	H183	ND	3.53	3.24
C. macrospora	E54	2.40	1.72	1.73
C. nitschkei	E53	3.31	1.20	0.61
	E59	1.30	0.83	0.48
C. parasitica		1.93	2.40	1.19
Average of 11 isolates				
C. radicalis	E16	0.48	0.26	0.36
	E42	0.26	0.76	0.60
	E56	0.28	0.27	0.42
	E64	1.19	0.50	0.44
	E67	1.52	ND	ND
	E76	0.44	0.60	0.56
	E150	0.53	0.68	1.41
	E152	1.04	ND	ND
E. coccolobii	E157	0.23	ND	ND
E. eugeniae	E138	1.00	1.20	ND
	E139	2.24	2.06	2.76
	H184	ND	2.06	ND
E. gyrosa		0.01	0.02	0.03
Test 1 - average of 13 isolates				
Test 2 - average of 11 isolates				
E. singularis	E58	0.01	0.01	0.02
E. viridistroma	E41	1.64	0.80	ND
	E82	0.91	0.72	2.60

[a] "ND" = not determined

cubensis) and brilliant yellow (*C. radicalis* and *C. cubensis*) pigments. Pigment production was inhibited among certain isolates of *E. coccolobii* (E157), *E. viridistroma* (E41), *C. macrospora* (E54), *C. cubensis* (H154) and *C. radicalis* (E76). Pycnidial production was decreased in cultures of *C. radicalis* (E42, E64), *C. gyrosa* (E57, E70), *C. coccolobii* (E157) and *C. cubensis* (H151, H154); the concentration required to elicit such an effect varied widely among the different species (0.01 - 10 µg/ml).

The mode of action of cycloheximide is quite specific; the compound disrupts protein synthesis at the 60S ribosomal subunit and may also inhibit DNA and RNA synthesis (15, 17). Differential sensitivities to cycloheximide have been reported for closely related organisms and

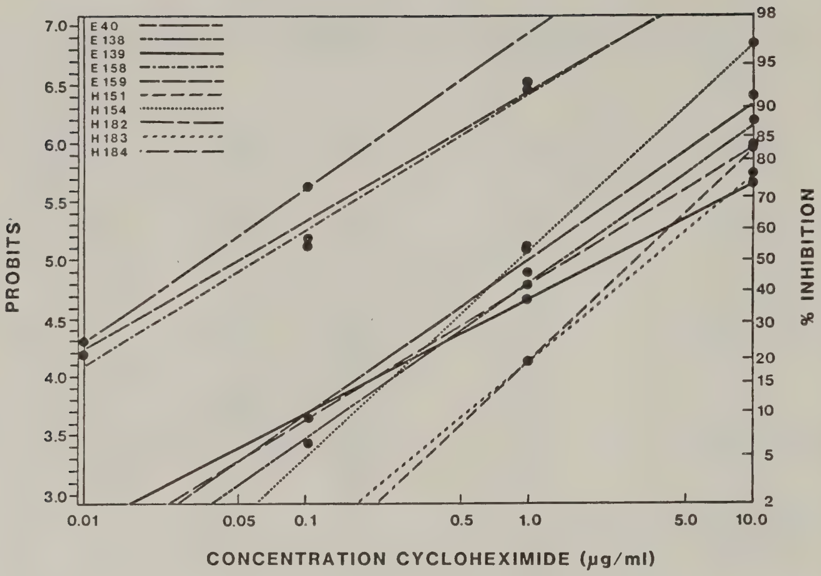

Figure 5. Dosage-response curve of *Cryphonectria havanensis* (E40, E158, E159, H183), *Endothia eugeniae* (E138, E139, H184) and *Cryphonectria cubensis* (H151, H154, H182) grown on cycloheximide-amended potato-dextrose agar at 25 °C for 7 d; average of three replicate plates per isolate. Concentration plotted on a logarithmic scale.

Table 4: Relative sensitivities of *Endothia* and *Cryphonectria* to cycloheximide.

Sensitive (ED_{50} < 0.1 ug/ml)	Insensitive (ED_{50} > 0.1 ug/ml)
C. havanensis?	*C. cubensis*
(E158 & E159)	*C. gyrosa*
E. gyrosa	*C. macrospora*
E. singularis	*C. parasitica*
	C. radicalis
	E. coccolobii[a]
	E. eugeniae[a]
	E. viridistroma

[a] Morphologically *Cryphonectria*.

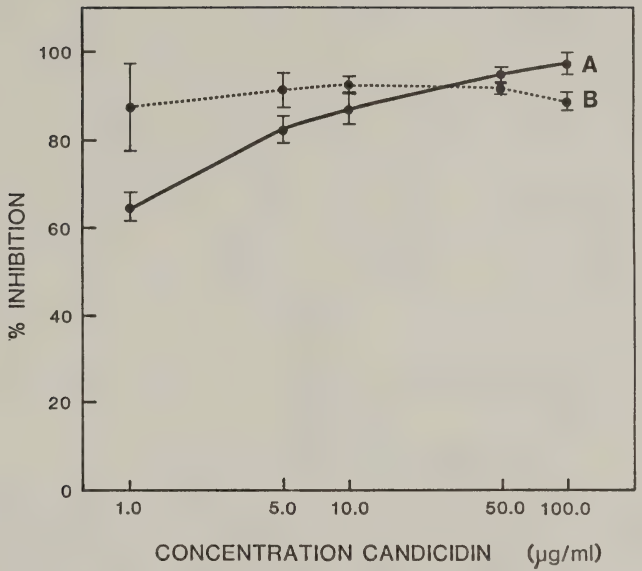

Figure 6. Dosage-response curve of Cryphonectria parasitica (A) and Endothia gyrosa (B) grown on candicidin-amended potato-dextrose agar at 25 °C for 8 d. Average of five isolates per species and two replicate plates per isolate. Vertical bars represent the standard deviation of the mean. Concentration plotted on a logarithmic scale.

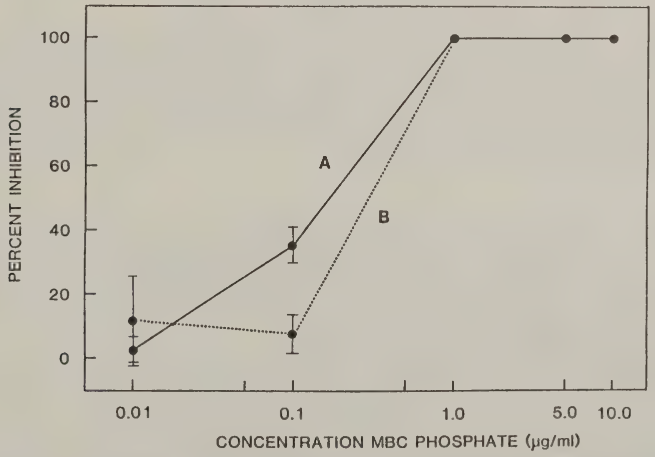

Figure 7. Dosage-response curve of Cryphonectria parasitica (A) and Endothia gyrosa (B) grown on MBC-phosphate-amended potato-dextrose agar at 25 °C for 8 d. Average of five isolates of C. parasitica and four isolates of E. gyrosa with two replicate plates per isolate. Vertical bars represent the standard deviation of the mean. Concentration plotted on a logarithmic scale.

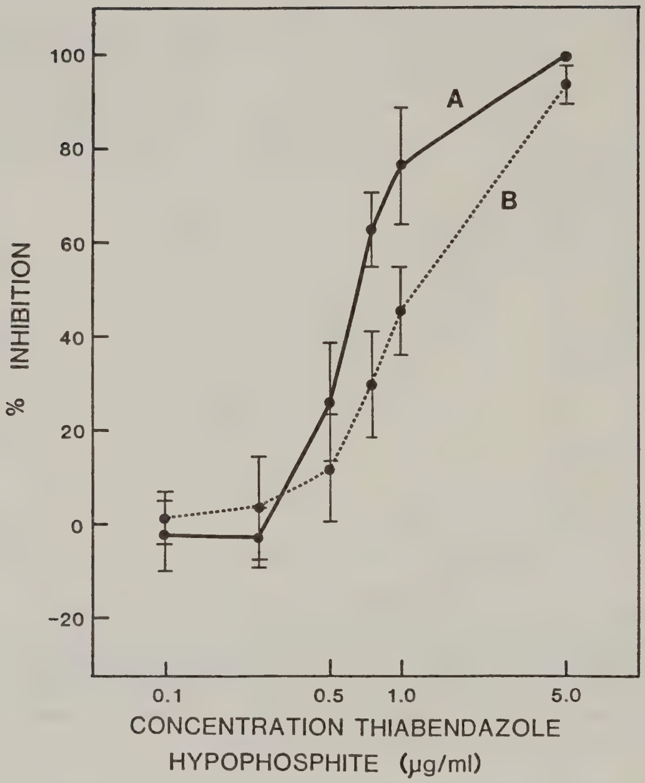

Figure 8. Dosage-response curve of *Cryphonectria parasitica* (A) and *Endothia gyrosa* (B) grown on thiabendazole hypophosphite-amended potato-dextrose agar at 25 °C for 8 d. Average of ten isolates of each species and two replicate plates per isolate. Vertical bars represent the standard deviation of the mean. Concentration plotted on a logarithmic scale.

frequently involve differences in ribosomal protein fractions (17). Some organisms, such as *Cunninghamella blakesleeana* Lender, can detoxify the compound; differences in membrane permeability have also been reported (15). Increased levels of pigment production are probably due to the processing of metabolites through preexisting secondary pathways in the absence of protein synthesis.

The remaining fungitoxicants did not cause such drastic differences in growth among isolates of *C. parasitica* and *E. gyrosa*. Several compounds induced differential sensitivities over at least a portion of the dosage response curve. This was observed with candicidin (Figure 6), MBC phosphate (Figure 7), thiabendazole hypophosphite (Figure 8) and chlorothalonil (Figure 9). Differences in response to these compounds were extremely limited and were not sufficient for their use in the formulation of selective media.

Cryphonectria parasitica and *E. gyrosa* formed similar dosage-re-

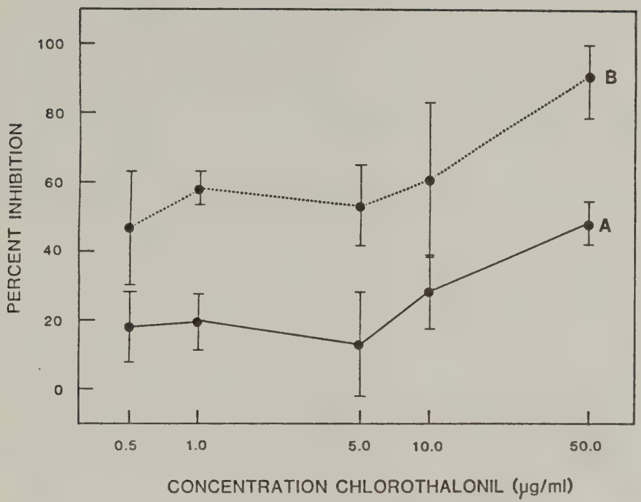

Figure 9. Dosage-response curve of Cryphonectria parasitica (A) and Endothia gyrosa (B) grown on chlorothalonil-amended potato-dextrose agar at 25 °C for 8 d. Average of four isolates of C. parasitica and two isolates of E. gyrosa with two replicate plates per isolate. Vertical bars represent the standard deviation of the mean. Concentration plotted on a logarithmic scale.

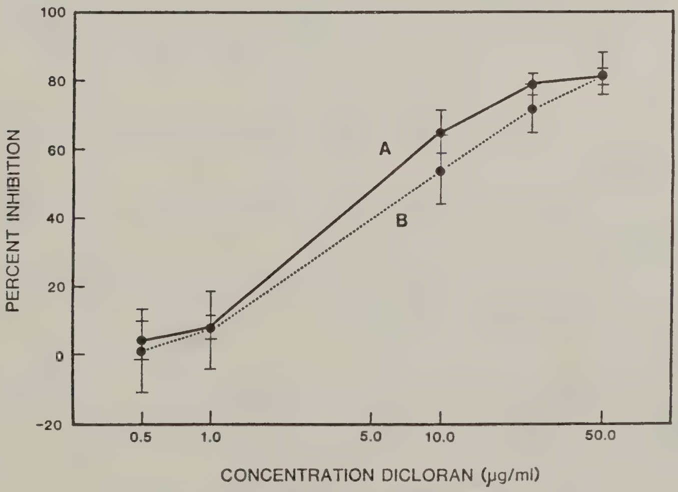

Figure 10. Dosage-response curve of Cryphonectria parasitica (A) and Endothia gyrosa (B) grown on dicloran-amended potato-dextrose agar at 25 °C for 8 d. Average of ten isolates of C. parasitica and nine isolates of E. gyrosa with two replicate plates per isolate. Vertical bars represent the standard deviation of the mean. Concentration plotted on a logarithmic scale.

sponse curves when exposed to the remaining fungitoxicants: nystatin, dicloran (Figure 10), chloramphenicol, captan, iprodione, vinclozolin, PCNB, amphotericin B, chloroneb, Fungisol^{R}, mancozeb, anilazine and triadimefon. Such uniformities in response suggest that the organisms may share many biochemical similarities and resistance mechanisms to fungitoxicants. Neither organism was sensitive to chlortetracycline, benzimidazole or fosetyl-Al. These results were expected since fosetyl-Al rarely inhibits *in vitro* growth of most fungi (3), and benzimidazole is not particularly fungitoxic (16). Chlortetracycline usually affects the mitochondrial ribosomes of eukayotes (15); it may be excluded from the cell or detoxified in some manner.

Cycloheximide sensitivity corresponded well with Barr's separation of *Endothia* and *Cryphonectria*. These data demonstrate that Barr's classification system reflects variations in fungal metabolism as well as morphology. The majority of fungitoxicants used in this study evoked a similar response by *C. parastica* and *E. gyrosa*. Such uniform reactions show that the organisms also share many biochemical pathways and resistance mechanisms to fungitoxicants. These studies show that differential sensitivities to fungitoxicants can provide the mycologist with additional means of studying relationships among fungal taxa.

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ON HAMIGERA, ITS RAPERIA ANAMORPH AND ITS CLASSIFICATION IN THE ONYGENACEAE

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Summary

Warcupiella spinulosa is transferred to Hamigera, and Penicillium ingelheimense to Raperia. Hamigera striata is classified in Byssochlamys and its anamorph in Paecilomyces. The Onygenaceae are delimited and restricted to Eurotiales with ellipsoidal, not bivalvate ascospores.

Raperia was introduced by Subramanian and Rajendran (1975) to accomodate the anamorph of Aspergillus spinulosus Warcup. This species was described for a fungus with a teleomorph and an anamorph. The generic name Raperia was meant for the anamorph; the teleomorph was classified in a separate genus as Warcupiella spinulosa (Warcup) Subramanian (1972). The genus Warcupiella was accepted by subsequent authors. Raperia, however, was considered a synonym of Aspergillus by Samson (1979).

Merimbla was introduced by Pitt and Hocking (1979) for Penicillium ingelheimense van Beyma, the anamorph of Talaromyces avellaneus (Thom & Turesson) C. R. Benjamin = Hamigera avellanea (Thom & Turesson) Stolk & Samson (1971). Pitt and Hocking (1979) synonymized Hamigera with Talaromyces.

A comparison of the two fungi shows that the teleomorphs as well as the anamorphs are congeneric. Common characters of the two species are:

Teleomorph: ascomata embedded in the aerial mycelium, without distinct peridium, surrounded or covered by sterile aerial hyphae; asci broadly clavate, borne from croziers, botryose, never catenate, rather persistent; ascospores broadly ellipsoidal, aseptate, with a thick, punctulate or spinulose wall, pale yellow, relatively large (7-13 x 5-10 µm).

Byssochlamys striata (Raper & Fennell) comb. nov.

Penicillium striatum Raper & Fennell - Mycologia 40: 521. 1948.
Talaromyces striatus (Raper & Fennell) C. R. Benjamin - Mycologia 47: 682. 1955.
Hamigera striata Stolk & Samson - Persoonia 6: 347. 1971.

anamorph:
Paecilomyces lineatus (Pitt) comb. nov.
Penicillium lineatum Pitt - Genus Penicillium p. 485. 1979.

Stolk and Samson (1971, 1972) distinguished *Talaromyces* from *Byssochlamys* and *Hamigera* by catenate asci, which are botryose in the last mentioned genera. This character is rather unsatisfactory for separating genera, but should be accepted. Stolk and Samson (1972) classified some anamorphs of *Talaromyces* in *Paecilomyces*. Species with green colonies and compact penicilli were maintained in the section *Biverticillata* of *Penicillium*. All species of this section should preferably be reclassified in *Paecilomyces*, because the respective teleomorphs belong to different families, viz. Onygenaceae and Eurotiaceae.

Paecilomyces can easily be distinguished from *Penicillium* s. str. by the shape of the conidiogenous cells and the size and shape of the conidia. *Paecilomyces* is characterized by lanceolate (acerose) conidiogenous cells with a tapering neck and by relatively narrow, often elongate conidia. Typical *Penicillium* species form ampulliform conidiogenous cells with a short neck and spherical or ovate, relatively broad conidia, similar to those of *Aspergillus*. *Penicillium* and *Aspergillus* are more closely related to each other than to *Paecilomyces* and *Raperia*.

The teleomorphs of *Aspergillus* and *Penicillium*, classified in *Eurotium*, *Emericella*, *Neosartorya*, *Eupenicillium* and other genera, form well defined ascomata with a thin or thick peridium, composed of angular, flattened or isodiametric cells. The ascospores are bivalvate, lenticular or saturnoid, never ellipsoidal as they are in *Hamigera* and *Byssochlamys*. The Eurotiales with ellipsoidal or occasionally fusiform or nearly spherical ascospores should be classified in a separate family, for which the name Onygenaceae is available (von Arx and van der Walt, 1986).

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Pages 120 and 121 were reversed; the Index to Taxa reflects the correct pagination.

Anamorph: conidiophores erect, coarse, relatively thick, apically inflated and successively forming compact, short branches and/or conidiogenous cells; conidiogenous cells cylindrical or ampulliform, apically forming a meristematic conidiogenous hypha which becomes septate in basipetal sequence; conidia ellipsoidal or short cylindrical, with distinct disjunctors.

The genera Hamigera and Raperia should be accepted for the teleomorphs and anamorphs of the two fungi, as follows:

Hamigera avellanea (Thom & Turesson) Stolk & Samson - Persoonia 6: 345. 1971.

Penicillium avellaneum Thom & Turesson - Mycologia 7: 285. 1915.
Talaromyces avellaneus (Thom & Turesson) C. R. Benjamin - Mycologia 47: 682. 1955.

anamorph:
Raperia ingelheimensis (van Beyma) comb. nov.

Penicillium ingelheimense van Beyma - Antonie van Leeuwenhoek 8: 109. 1942.
Merimbla ingelheimense (van Beyma) Pitt - Can. J. Bot. 57: 2395. 1979.

Hamigera spinulosa (Warcup) comb. nov.

Aspergillus spinulosus Warcup in Raper & Fennell - The genus Aspergillus p. 204. 1965.
Warcupiella spinulosa (Warcup) Subramanian - Curr. Sci. 41: 757. 1972.
Sporophormus spinulosus (Warcup) Malloch & Cain - Can. J. Bot. 50: 2624. 1972.

anamorph:
Raperia spinulosa Subramanian & Rajendran - Kavaka 3: 129. 1975.

Stolk and Samson (1971) considered Hamigera to be closely related to Byssochlamys, which was distinguished by spherical asci, smooth ascospores, and a Paecilomyces anamorph. They classified a second species in Hamigera, H. striata Stolk & Samson, based on Penicillium striatum Raper & Fennell. This species is not congeneric with Hamigera avellanea. Its anamorph is a typical member of Paecilomyces and the teleomorph differs from the other species of Byssochlamys only by the longitudinally striate ascospores. The following namenclatural changes are proposed:

Onygenaceae Fr. (incl. Monascaceae and Trichocomaceae)

Ascomatal initials usually represented by clavate or cylindrical ascogonia surrounded by coiled antheridia; ascomata pustulate, hemispherical or spherical, occasionally stalked or synnematous, usually without a distinct peridium, often covered or surrounded by a weft of hyphae or without any covering; asci spherical or clavate, often with a short stalk, occasionally catenate; ascospores ellipsoidal or elongate, aseptate, smooth, spinulose or striate, occasionally with longitudinal furrows or wings, never bivalvate or oblate; anamorphs often present; conidia catenate, with disjunctives or separating cells; colonies often with red exudates; often keratinolytic or osmophilic.

Representative genera: *Onygena* Fr. (with stalked ascomata), *Byssochlamys* Westling, *Talaromyces* C. R. Benjamin, *Hamigera* Stolk & Samson, *Penicilliopsis* Solms-Laubach, *Trichocoma* Jungh., *Sagenoma* Stolk & Orr, *Thermoascus* Miehe, *Byssoascus* v. Arx, *Pseudoarachniotus* Raillo, *Myxotrichum* Kunze, *Monascus* van Tieghem, *Monascella* Guarro & v. Arx.

Anamorphs: *Paecilomyces* (including *Penicillium*, sect. *Biverticillata*, *Phialotubus* Roy & Leelavathy, *Sagenomella* W. Gams, *Septofusidium* W. Gams), *Phialomyces* Misra & Talbot, *Acrophialophora* Edward, *Oidiodendron* Robak, *Coremiella* Bubak & Krieger, *Basipetospora* Cole & Kendrick.

The Dipodascaceae and other genera of the Endomycetales with ellipsoidal ascospores are related to the Onygenaceae. Several *Dipodascus* species include *Geotrichum* anamorphs, in which the catenate conidia also seceed by disjunctives.

The Erysiphaceae (powdery mildews) are similar to the Onygenaceae in that they have non-ostiolate ascomata, spherical or obovate asci and aseptate, ellipsoidal ascospores. Their *Oidium* anamorphs form aseptate conidia with truncate ends in basipetal chains from a meristematic zone of an erect conidiogenous hypha. The conidia release easily under dry conditions, as do the conidia of many Onygenaceae.

The teleomorphs of *Aspergillus* and *Penicillium* should be classified in the Eurotiaceae. Typical Gymnoascaceae have similar, bivalvate or lenticular ascospores, but can be distinguished from the Eurotiaceae by the structure of the ascomatal wall, which is composed of a network of stiff hyphae or is absent. The Gymnoascaceae include only a few genera, e.g. *Gymnoascus*, *Gymnascella*, *Narasimhella*, *Arthroderma*, *Nannizzia* and *Ctenomyces*.

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GLOMUS MICROAGGREGATUM, A NEW SPECIES IN THE ENDOGONACEAE

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Examination of soil samples from maritime and lacustrine sand dunes of North America and Hawaii for vesicular-arbuscular mycorrhizal (VAM) fungi revealed an undescribed species of *Glomus* of common occurrence that routinely sporulated inside dead spores of other VAM fungi.

Spores were extracted from soil samples by wet-sieving and filtration (Koske and Walker, 1984) or by sucrose centrifugation (Walker, Mize and McNabb, 1982). Spore wall terminology follows that of Walker (1983), and descriptions are based upon the appearance of spores mounted in a polyvinyl alcohol/glycerol/latic acid solution (PVLG) (Koske and Tessier, 1983). Collections have been deposited in the herbarium of Oregon State University (OSC: holotype), the Farlow herbarium (FH: isotype) and at Kew (K: isotype).

SPECIES DESCRIPTION

GLOMUS MICROAGGREGATUM Koske, Gemma & Olexia sp. nov. Figs. 1-9

Sporae in solo efformatae. Hyalinae vel pallide luteolae vel fulvae, globosae vel irregulares; (15-)30(-50) µm x (15-)30(-40) µm. Sporae tunica e strato uno vel duobus (1-2) in uno turmo; exteriori levi et fragili, hyalinae vel pallide luteolo vel fulvo, 0.5-1.2(-2) µm crasso; interno membranaceo, concolori cum exteriori, <0.5-1.2(-2) µm crasso. Hypha concolor cum exteriori, levis vel infundibuliforma, 1. 8-3(-4.5) µm lata prope sporam, stratum ad 1.5(-12) µm crassum.

Sporocarps unknown. *Spores* formed singly in the soil, in roots, or in clusters inside dead spores of other Endogonaceae; hyaline to pale yellow to brownish-yellow in transmitted light; globose or subglose to irregular (15-) 30(-50) x (15-)30(-40) µm diam. *Spore wall structure* (see murograph, Fig. 8) of one or two walls (1-2) in one group. Wall 1 a smooth, brittle unit wall, hyaline to pale yellow to brownish-yellow, 0.5-1.2(-2) µm thick. Wall 2, if present, a membranous or unit wall, concolorous with wall 1, <0.5-1.2(-2) µm thick. *Attachment hypha* concolorous with wall 1, straight or infundibuliform, 1.8-3(-4.5) µm wide at spore base, wall up to 1.5(-2) µm thick. Pore usually open, sometimes closed by a septum formed by wall 2 distending into the attachment hypha.

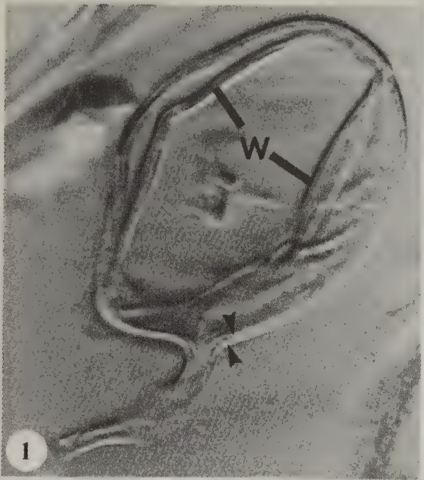
MYCORRHIZAL ASSOCIATIONS: Associated in the field with roots of *Abronia maritima* Nett. ex Wats., *Ambrosia chamissonnis* Less., *Ammophila breviligulata* Fern., *Calamovilfa longifolia* (Hook.) Scribn., *Ipomoea brasiliensis* (L.) Sweet, *Malacothrix incana* (Nutt.) T. & G. *Pennisetum setaceum* (Forsk.) Chiov., *Sporobolus* sp., *Prunus pumila* L., and *Uniola paniculata* L. Pot cultures were not attempted.

ETYMOLOGY: named for the resemblance of the spores to those of the larger-spored *Glomus aggregatum* Schenck & Smith.

DISTRIBUTION AND HABITAT: Known from sand dune soils in California, Hawaii, Michigan, and the Atlantic coast of the United States. Spores are seldom found freely in the soil. They routinely are found by crushing dead spores of other species of VAM fungi, where they occur in groups of 100 or more.

COLLECTIONS EXAMINED: HOLOTYPE: MICHIGAN - Benzie Co., Sleeping Bear Dunes State Park, among roots of *Calamovilfa longifolia* (Olexia 62, 16 Oct. 1984). OTHER COLLECTIONS: CALIFORNIA - Santa Barbara Co., San Miguel Island (Koske 575, 576, 581, 5 July 1984); HAWAII - Hawaii Co., Kailua (Koske 804, 806-810, 17 July 1984), Hapuna Beach State Recreation Area (Koske 816, 18 July 1984); MARYLAND - Worcester Co., Assateague Island (Koske 432, 14 Mar. 1982); MICHIGAN - Allegan Co., Saugatuck Dunes State Park (Olexia 109 25 Oct. 1984); RHODE ISLAND - Washington Co., Moonstone Beach (Koske 440, 15 Mar. 1982), Virginia Beach Township, Seashore State Park (Koske 518, 524, 526, 23 April 1983); WISCONSIN - Bayfield Co., Cornucopia Beach (Tews 049, 050, 3 July, 1985).

Figs. 1-5. *Glomus microaggregatum*. 1. Spore with two unit walls well separated at spore base (arrows). Note wrinkling (W) of walls 1 and 2 that occurred when the spore was mounted, X1090. 2 Spores inside dead spore of *Gigaspora* sp. Wall of *Gigaspora* is indicated (arrows), X335. 3. Spore with wrinkles in walls (arrows), X710. 4. Spores with two equal unit walls. Note separation near base of the lowermost spore (arrows) and wrinkling (W) of walls 1 and 2, X615. 5. Spores with a membranous wall 2 which has folded and wrinkled (arrows), X360.



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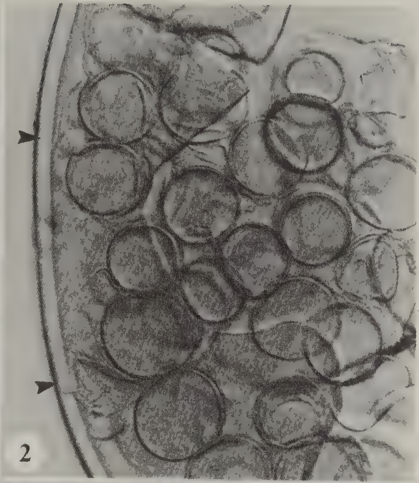

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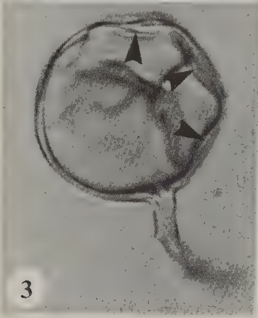

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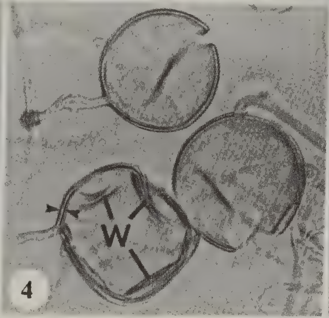

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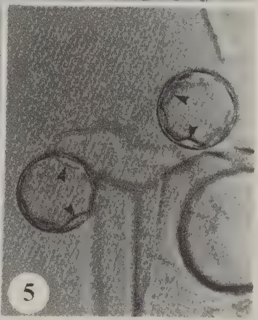

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DISCUSSION

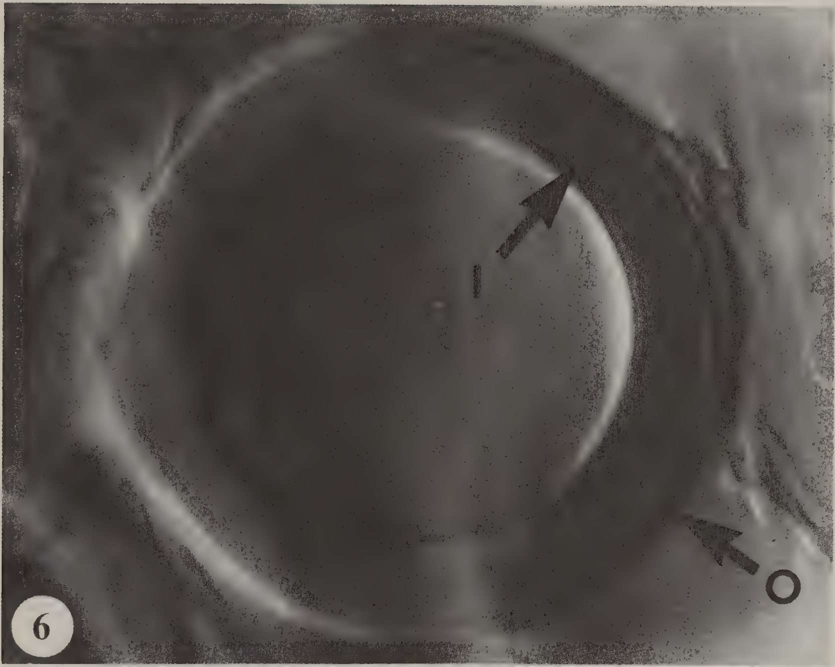
Glomus microaggregatum is distinguished from other species by the small size of its spores, the spore wall structure, the hyaline to very pale yellow or brownish-yellow color of the spores, and the narrow attachment hypha. In most spores, the wall structure consists of two unit walls with the innermost one equal in thickness to the outermost (usually 0.8-1.0 μm each) (Fig. 4) or slightly thinner (ca. 0.5 μm) than the outermost wall (Figs. 1,5). Included in a single spore cluster were spores with two equal unit walls, two sub-equal unit walls, an outer unit and an inner membranous wall (Fig. 5), and spores with apparently a single unit wall (Fig 4). It appears that the innermost wall forms after the outermost wall and progresses from a wrinkling, membranous type wall (Walker, 1983) to a thicker, more rigid, unit wall. Such a sequence of development has been suggested for the spore wall structure of *G. aggregatum* (Koske, 1985).

The double nature of the spore walls of *G. microaggregatum* often is most apparent at the base of the spore where it joins the attachment hypha, (Figs. 1, 4), and the two walls may continue down the subtending hypha for a distance of 15 μm.

Glomus microaggregatum most resembles *G. aggregatum* in the variation in spore wall structure that is apparent in spores in different stages of development, the range of spore shapes produced, and the propensity to sporulate inside of its own spores and inside of dead spores of other VAM fungi (Koske, 1985) (Fig. 2). It can be distinguished from *G. aggregatum* (average spore diam. 60-85 μm) by its smaller spores (typically 30-40 μm diam.) (Fig. 9) and their lighter color. The two species occasionally occur together and are easily separated by these two criteria.

Four species of *Glomus*, *G. occultum* Walker, *G. diaphanum* Morton & Walker, *G. microcarpum* Tul. & Tul., and *G. pubescens* (Sacc. & Ellis) Trappe & Gerd. produce small, hyaline or sub-hyaline spores that could be confused with those of *G. microaggregatum*. *Glomus occultum* resembles *G. microaggregatum* in the variation in spore shape, and spore sizes of the two species overlap (15-100 x 20-100 μm for *G. occultum* and 15-50 x 15-40 μm for *G. microaggregatum*). However, spores of *G. occultum* possess three walls of equal thickness, and no inner wrinkling wall is present during development (Morton, 1983). Furthermore, spores of *G. occultum* often appear roughened, while those of *G. microaggre-*

Figs. 6,7. Spores of similar *Glomus* species. 6. *Glomus microcarpum* (from Type material). Spores mounted in PVLG. Note apparent outermost wall (0) and thick inner wall (I), X2000. 7. *Glomus pubescens*. Spores mounted in water. Note thick outer wall (0) and membranous, wrinkling inner wall (I), X425.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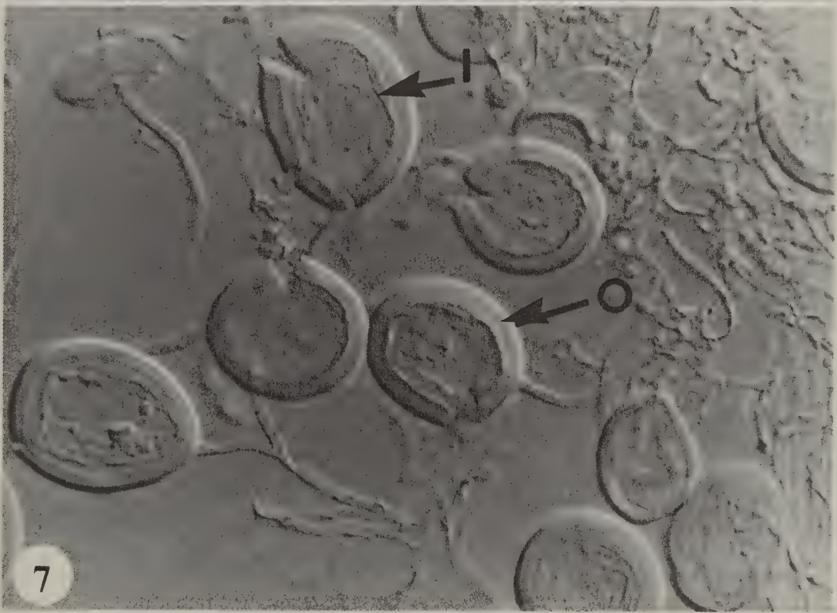
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gatum usually are smooth and, although sometimes hyaline when fresh, are pale yellow to yellow-brown after a few days in the PVLG mounting solution. The subtending hypha of spores of *G. microaggregatum* is very narrow, averaging about 3 µm wide compared to an average of about 4.3-6.5 µm for *G. occultum* (Morton, 1985). In addition, the walls of the subtending hypha of *G. occultum* are usually very thin (0.5 µm), while those of *G. microaggregatum* are usually 1 µm or more thick.

Spores of *G. diaphanum* possess an inner membranous wall that resembles wall 2 in some spores of *G. microaggregatum*. The outer wall of *G. diaphanum* is much thicker (2-6.5 µm) than that of the latter species. Also, spores of *G. diaphanum* typically are larger (39-121 µm diam) than those of *G. microaggregatum*. After a few weeks in PVLG, the hyaline spores of *G. diaphanum* and *G. occultum* turn a pale yellow color similar to that of spores of *G. microaggregatum*.

Glomus microcarpum produces spores similar in size and color to those of *G. microaggregatum*, but those of the former possess a laminated wall that is thicker (4-6 µm) than either of the two walls of *G. microaggregatum*. Berch and Fortin (1984) interpreted the spore wall structure of *G. microcarpum* as consisting of a single wall of the laminated type (Walker, 1983). Examination of Berch and Fortin's material by one of us (REK) led to a different interpretation: an outer unit wall (wall 1) surrounds a thick, laminated wall (wall 2) (Fig. 6). Berch (pers. comm.) believes that the apparent outermost wall is an artefact resulting from the lactic acid causing the outermost lamination of the laminated wall to separate, giving the appearance of a distinct unit wall. Regardless, the thick-walled spores with their wide subtending hyphae (4-8.5 µm) clearly are distinguishable from those of *G. microaggregatum*.

Glomus pubescens resembles *G. microaggregatum* in the size and color of its spores and in the narrowness of the attached hypha. However, spores of the former possess a robust laminated wall 2-7 µm thick (av. 3-4 µm) and are known to be produced only in well-organized sporocarps with distinctive peridial hyphae that form tufts on the surface of the sporocarp (Gerdemann and Trappe, 1974). Spores of *G. pubescens*, as seen in Thaxter's collections in the Farlow Herbarium, are more similar to those of *G. microcarpum* than to *G. microaggregatum*. In water mounts, spores of *G. pubescens* possess a thick outermost laminated wall to which is appressed an inner wrinkling, membranous wall 0.5 µm thick (Fig. 7). Spores mounted in PVLG appear to have an additional wall, a thin, outermost unit wall 1-2 µm thick appressed to the laminated wall.

Spores of *G. microaggregatum* were seldom found occurring freely in the soil. Unless the contents of dead spores of other VAM fungi were examined or roots were crushed open, spores of this species would have been overlooked.

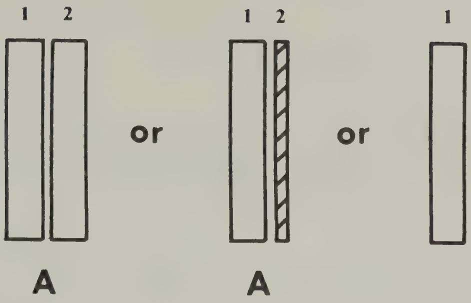

Fig. 8. Murographs of spore wall structure of Glomus microaggregatum. Spores with two walls predominate in most collections. See Text for explanation.

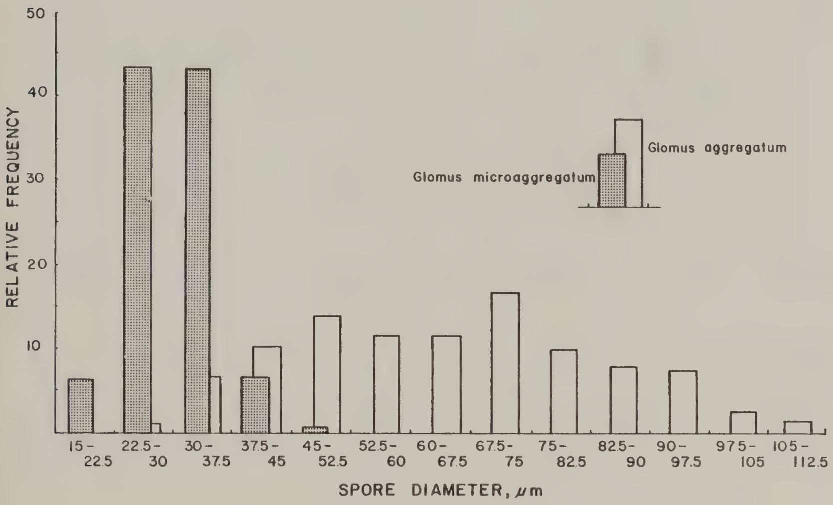

Fig. 9. Spore diameter frequency diagram. For non-globose spores, only the largest diameter was measured. Data for Glomus microaggregatum are from 5 collections representing 210 spores. For Glomus aggregatum, data are from 7 collections representing 189 spores.

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GLOMUS GLOBIFERUM: A NEW SPECIES OF ENDOGONACEAE WITH A HYPHAL PERIDIUM

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In a study of species of vesicular-arbuscular mycorrhizal (VAM) fungi associated with sand dune colonizing plants of the Atlantic Coast of the United States of America, a new species of *Glomus* with individual chlamydospores surrounded by an unusual peridium was discovered. Spores were extracted by the wet-sieving/filtration method (Koske & Walker 1984) from soil sampled from around the roots of American beachgrass *Ammophila breviligulata* Fern. The new species was found originally in only one sample from more than 500 taken from dunes of the North and Mid-Atlantic coast, but was later discovered in sand dune samples from Virginia and Michigan.

Specimens have been deposited in the herbaria at Oregon State University (OSC) the Farlow Herbarium (FH), and Kew (K). Wall descriptions and terminology are those suggested by Walker (1983, 1986), and descriptions are based on the appearance of specimens in a polyvinyl alcohol mountant (Koske and Tessier, 1983, Walker, 1983).

SPECIES DESCRIPTION

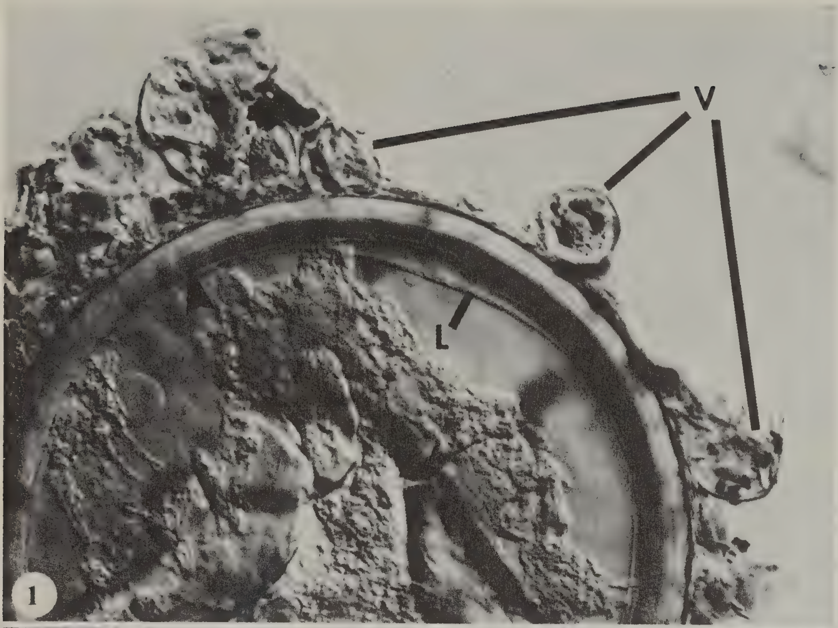
GLOMUS GLOBIFERUM Koske et Walker sp. nov. Figures 1-12.

Sporocarpia ignota. Sporae singillatim, binatim, vel trinatim enatae, cinnamomeae, porphyreae, vel raro atrofuscae, globosae vel subglobosae, 150-260 x 150-270 μm, peridium hyphae laxae et sparce septatae vel collapsae exclusum. Tunica sporae stratis tribus vel quatuor in turmis uno vel duabus. Ubi in turma una, stratis tribus vel quatuor arcte adhaerentibus: stratum extimum hyalinum vel pallide hepaticum, 0.5-3 μm crassum, stratum duo laminatum, cinnamomeum vel porphyreum, 6-30 μm crassum, laminis usque ad 9, subaequalibus, saepe indistinctis; strata tria et quatior hyalina, membranacea, utrumque circa 1 μm crassum. Ubi in turmis duabus, turma externa stratis duabus: stratum extimum hyalinum vel pallide hepaticum 0.5-3 μm crassum, ad stratum internum, cinnamomeum vel porphyreum, 6-30 μm crassum, laminis usque ad 9, subaequalibus, saepe indistinctis, haerens. Turma interna strato uno, hyalino, membranaceo, 1 µm crasso; vel stratis duobus, hyalinis, membranaceis, utrumque circa 1 µm crassum; vel strato uno, coriaceo, 2-3 µm crasso. Hyphae sustentantes, crasse tunicatae prope sporam, inferne mox tenuiter tunicatae e hyalinae, strictae vel recurvae, plerumque proximale constrictae vel interdum strictae vel infundibuliformes, 15-27 µm crassae ad basim sporae, 18-37 µm crassae ad locum latissimum. Peridium hyphis hyalinis vel hepaticis, tenuiter tunicatis, 5-20 µm crassis, tumoribus numerosis, terminalibus vel intercalaribus, globosis vel ovoideis, vacuis vel contentu granulosis vel cinnamomeis, 12-65 x 12-75 µm crassis. Tumorum tunicae 1-2.5 µm crassae, stratis duobus.

Sporocarps unknown. Spores formed singly, or in pairs or triplets adhering to each other by common peridial hyphae; orange brown to rich red-brown, to (rarely) fuscous black; globose to subglobose, 150-260 x 150-270 µm, excluding the peridium. *Spore wall structure* (see murograph, Fig. 12) of an outer peridium (P) that may be of loose, sparsely septate hyphae, or of compacted, collapsed hyphae, surrounding 3 or 4 walls (walls 1-4) in 1 or 2 groups (group A or groups A & B). When in a single group, group A consisting of 3 or 4 tightly adherent walls. Wall 1 a hyaline to pale yellow-brown unit wall, 0.5-3 µm thick. Wall 2 laminated, orange-brown to red-brown 6-30 µm thick, with up to 9 subequal laminae that often are indistinct. Walls 3 & 4 hyaline, membranous, each approximately 1 m thick. When in two groups, group A consisting of a thin unit wall (wall 1) tightly adherent to a thick laminated wall (wall 2). Wall 1 hyaline to pale yellow-brown, 0.5-3 µm thick. Wall 2 orange-brown to red-brown, 6-30 µm thick, with up to 9 subequal laminae that often are indistinct, and that may be somewhat loose toward the interior of the spore. Group B a single, hyaline, membranous wall (wall 3) 1 µm thick (Fig. 3), or a pair of hyaline, membranous walls (walls 3 & 4), each approximately 1 µm thick and apparently attached to each other by a thin, amorphous cement-like layer (Fig. 7); or a single, coriaceous wall, 2-3 µm thick.

Subtending hyphae thick-walled proximally, but with the wall thickness rapidly diminishing from the point of connection to a thin-walled, hyaline, sparsely septate, parent hypha; straight or recurved; usually constricted proximally but occasionally straight or funnel-shaped; 15-27 µm wide at the spore base, 18-37 µm at the widest point, with the wall 2-8 µm thick; pore in the spore wall closed partially by ingrowth of the inner laminae of the spore wall and partially by a granular plug. At the spore base, the subtending hypha usually appears to be inserted into the spore wall. Subtending hypha typically breaking off at the constriction, or from the parent hypha, 25-85µm below the spore base.

Figs. 1-2. *Glomus globiferum*. 1. Crushed spore with vesiculate swellings (V) of peridial hyphae. Note laminations of wall 2 (arrow) and loose lamination (L), X235. 2. Crushed spores with abundant vesiculate swellings of the peridial hyphae, X145.



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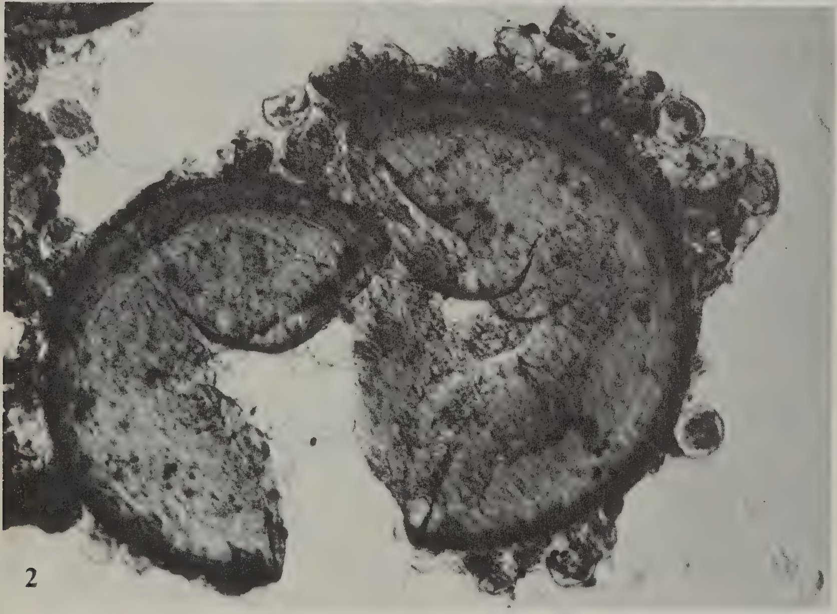


2

Peridium of loosely interwoven hyaline to yellow-brown, coenocytic or sparsely septate, thin-walled hyphae, 5-50 μm broad, bearing numerous terminal or intercalary globose to ovoid, pale yellow-brown or hyaline vesiculate swellings that have a shape and form similar to Glomus chlamydospores, and that either are empty, or have granular, orange-brown contents. Vesiculate swellings 12-65 x 12-75 μm, with walls 1-2.5 μm thick, consisting of a thin, hyaline outer unit wall, and a thicker, slightly colored inner laminated wall. The vesicle contents plasmolyze when specimens are placed in a hypertonic solution, but there is no sign of an enclosing membranous wall under light microscope observation. As the spores age, the peridial hyphae loose their contents and collapse to form a tight envelope of indistinctly plectenchymatous tissue.

DISTRIBUTION AND HABITAT

The species is known from the root zone of A. breviligulata growing in sand dunes at Cape May, New Jersey. The sand had a pH of 6.5 and a chloride level of 8.8 ppm. It also is known from beneath plants of A. breviligulata from Seashore State Park, Virginia and from the root zone of Artemesia sp. growing in sand dunes on the shores of Lake Michigan near Grand Mere, Michigan.

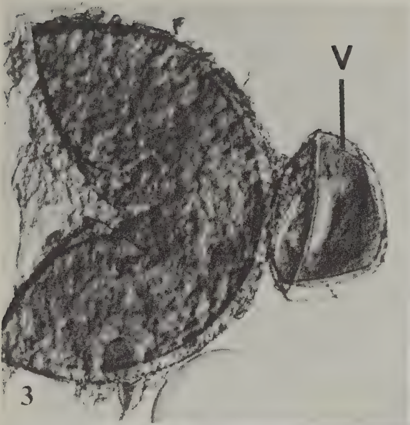
MYCORRHIZAL ASSOCIATIONS

The mycorrhizal associations of Glomus globiferum are unknown. It is associated, but not proven mycorrhizal, with A. breviligulata and a species of Artemesia. Attempts to establish the species in pot culture with onion, clover, and soybean have failed.

ETYMOLOGY

From the Latin, globiferum (="sphere bearing"), referring to the spherical or near-spherical vesiculate swellings produced by the peridial hyphae on the outside of the spore.

Figs. 3-9. Glomus globiferum. 3. Crushed spore with a large vesiculate swelling of peridial hypha. Rough appearance of spore is caused by the peridial hyphae, X140. 4. Crushed spore with innermost membranous wall visible (arrow), X140. 5, 6. Subtending hyphae. Note thick wall (arrow) on one side of the subtending hypha in 6, X550. 7. Spore walls. The thick no. 2 wall is shown as are the two membranous walls (walls 3 and 4) of wall group B, X1390. 8. Subtending hypha with unevenly thickened walls. Note thick wall (arrow) and vesiculate swelling of peridium, X550. 9. Peridial hyphae. Collapsed, irregular hyphae on spore surface, X550.



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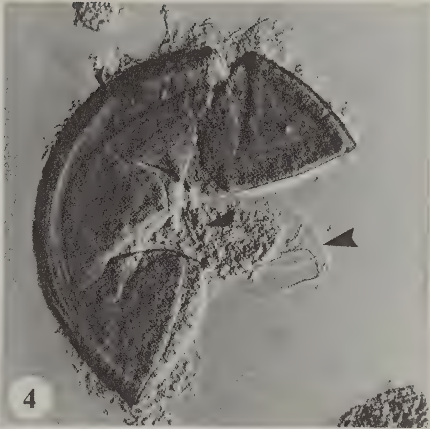

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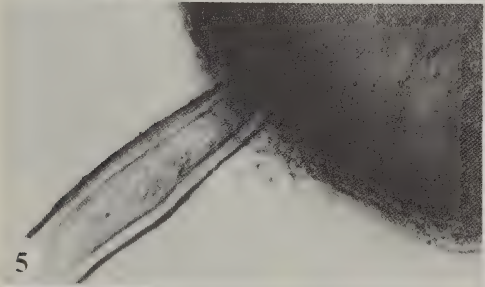

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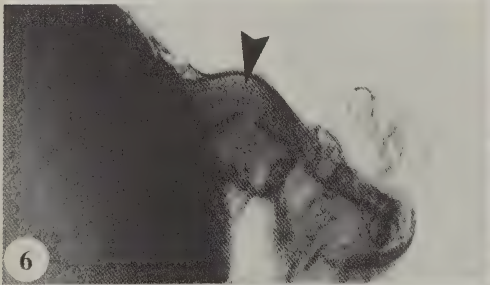

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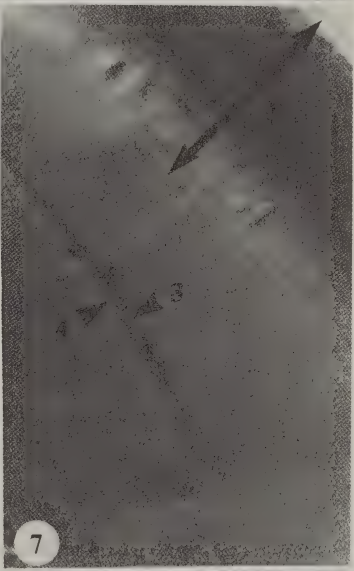

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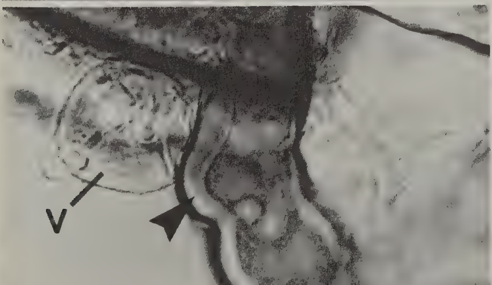

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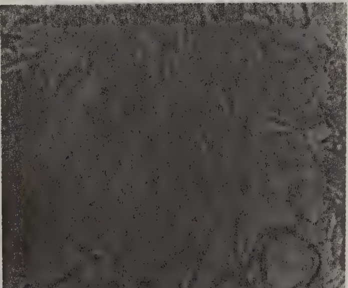

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COLLECTIONS EXAMINED

HOLOTYPE: NEW JERSEY - Cape May County, Cape May. Among roots of A. breviligulata, 14 March 1982. Koske 400, Walker 535. (OSC; Isotypes FH, K). OTHER COLLECTIONS: VIRGINIA-Virginia Beach Township, Seashore State Park. Among roots of A. breviligulata, 23 April 1983. Koske 519: MICHIGAN - Berrien County, Grand Mere. Among roots of Artemesia sp., 23 August 1984. P. Olexia 8.

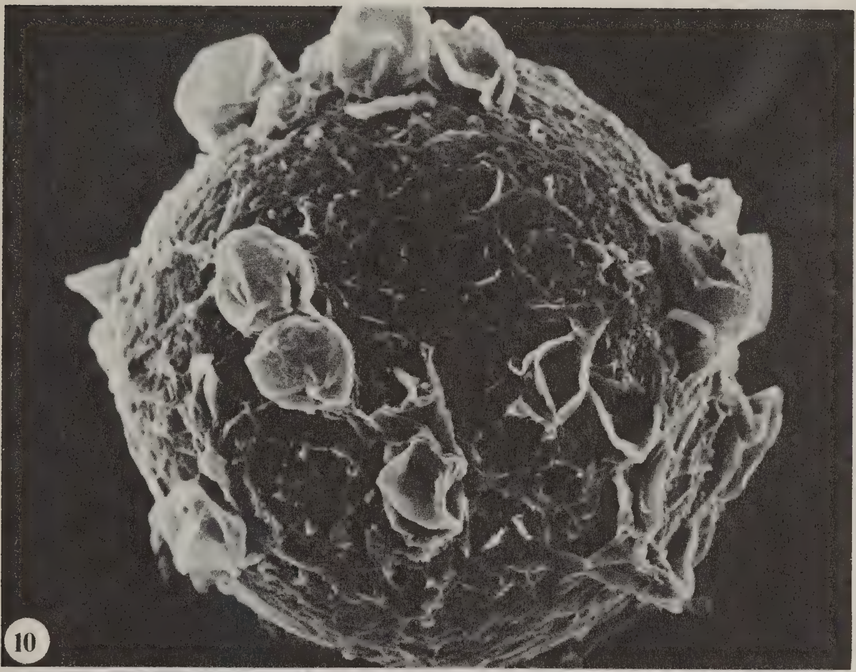
DISCUSSION

The peridial hyphae and their associated vesiculate swelling are particularly striking in this fungus (Figs. 1, 2, 3, 8-11). Although this species has not been maintained in pot culture, the color of the field-collected spores and the appearance of their contents indicate that younger specimens have a loose weft of clearly distinguishable hyphae bearing the swellings, and the hyphae collapse to become plate-like as the spores age. When this collapse has occurred, it is difficult to distinguish individual hyphae in the peridium (Figs. 9, 11). The vesiculate swellings have the general appearance of small spores of a Glomus species. In common with spores, these vesiculate swellings may demonstrate wall thickening and the presence of septa occluding the contents, and under such circumstances, could perhaps be secondary chlamydospores.

The hyphal peridium was poorly developed on some spores in collections from New Jersey and Michigan. The collapsed hyphae on the spore surface were evident only at 1000X magnification, and these unusual specimens lacked the typical vesiculate swellings. The spores could be identified by their wall composition and the features of their hyphal attachment. A similar lack of peridial development can occur with some spores of Glomus tortuosum Schenck & Smith (Koske, personal observation).

The colored wall (wall 2) of G. globiferum is coarsely laminated, though the laminae are not always distinct. In some specimens, the innermost 1 or 2 laminae may separate from the rest when specimens are crushed on a microscope slide (Fig. 1), and thus give the erroneous impression of additional individual unit walls. Examination of a series of specimens will show that this is an artifact, and that this phenomenon does not occur consistently on spores of similar development.

Figs. 10-11. Glomus globiferum. S.E.M. of spores. 10. Whole spore with peridium and vesiculate swellings, some of which have collapsed, X450. 11. Spore surface showing vesiculate swellings and collapsed peridial hyphae, X1175.



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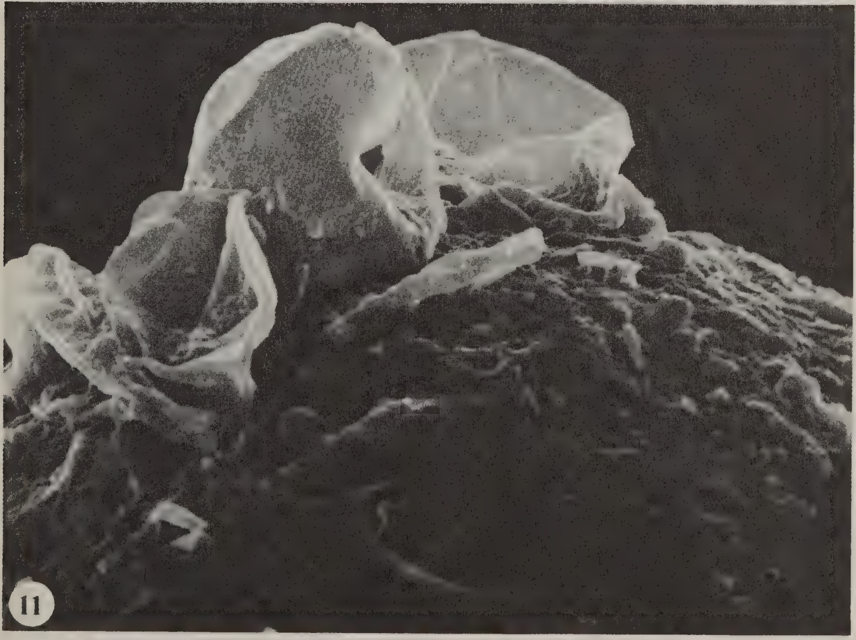

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The constriction of the subtending hypha at the point of attachment to the spore is reminiscent of *G. constrictum* Trappe (1977), but, unlike that species, because of the way that the spore contents are occluded, the hypha often appears to be "inserted" into the wall of the spore. This phenomenon was originally reported for *G. epigaeum* Daniels & Trappe (= *G. versiforme* (Karsten) Berch), and is well illustrated by Daniels & Trappe (1979).

Collections in which most spores have been separated from their subtending hyphae at the point of attachment may be mistaken for an *Acaulospora* species, especially if the peridial hyphae and vesicles have collapsed. Examination of the spores at 1000X will reveal the characteristic peridium and wall structure.

Glomus tortuosum resembles *G. globiferum* in possessing a hyphal peridium and having spores that occasionally adhere in pairs, but the peridial hyphae of the former do not have vesiculate swellings, and are denser, and distinctly sinuate (Schenck and Smith, 1982). In addition, G. *tortuo-*

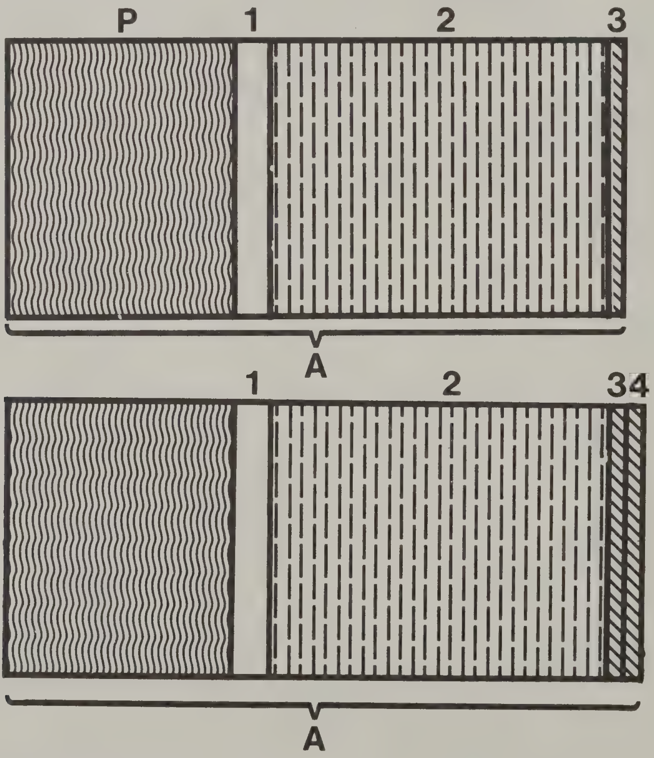
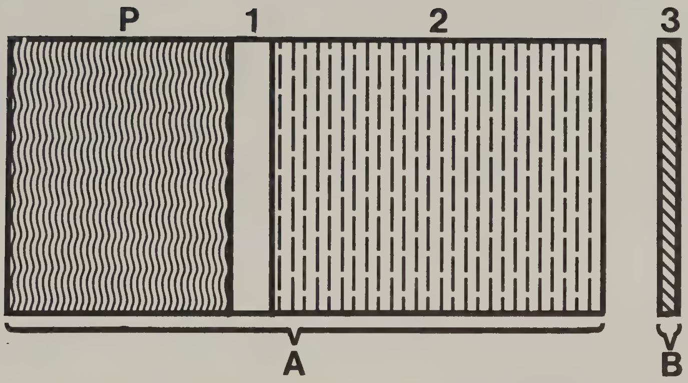
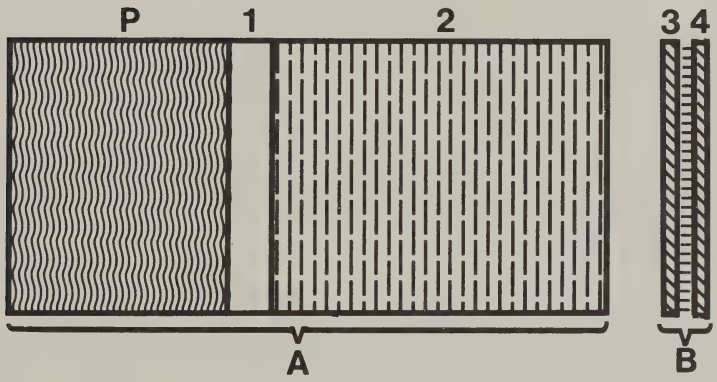
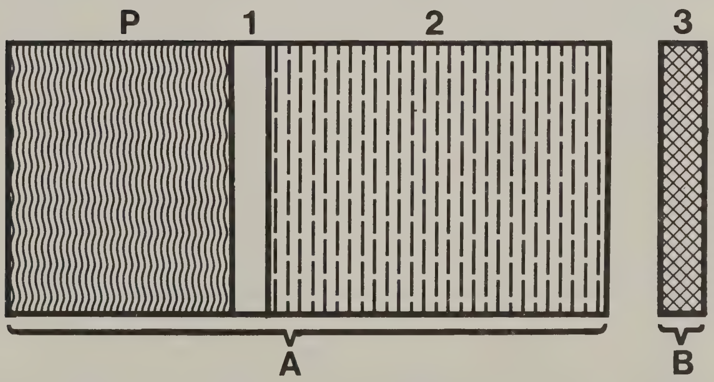


Fig. 12. Murographs of spore wall structure of *Glomus globiferum*. Five possible variations are shown above and on the facing page. See text for explanation.


P
1
2
3
A
B


P
1
2
3
4
A
B


P
1
2
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sum spores are somewhat smaller than those of G. globiferum, although their size ranges do overlap. Spores of G. tortuosum are a smokey grey-brown color when viewed through a dissecting microscope, while those of G. globiferum typically are orange-brown to red-brown. Other species of Glomus that may have hyphal peridia are G. mosseae (Nicol. & Gerd.) Gerd. & Trappe, G. convolutum Gerd. & Trappe, and G. monosporum Gerd. & Trappe (Gerdemann and Trappe, 1974). None of these species has vesiculate swellings or are as dark as G. globiferum.

ACKNOWLEDGEMENTS

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GLOMUS PUSTULATUM: A NEW SPECIES IN THE ENDOGONACEAE

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Examination of soil samples from around roots and rhizomes of American beachgrass (Ammophila breviligulata Fern.) growing on the berm and the dunes of Moonstone Beach, Rhode Island, revealed a previously undescribed species of Glomus Tul. & Tul. with a distinctive outer wall. Spores were recovered from soil by the wet-sieving and filtration method (Koske and Walker, 1984). The species was later discovered in the root zones of sea purslane (Honkenya peploides (L.) Erh. (=Arenaria peoloides L.)) and sea pea (Lathyrus maritimus Bigel, (=L. japonicus Willd.)) growing in sandy shores in Quebec, Canada. Wall descriptions follow the suggested standardization of Walker (1983, 1986) and are based upon the appearance of freshly collected spores mounted in a polyvinyl alcohol based mountant (PVL or PVLG) (Walker 1983, Koske and Tessier 1983). Specimens preserved in PVLG or 5% formalin have been deposited in the herbaria of Oregon State University (OSC), the Farlow (FH), the Herbarium of the Department of Agriculture, Ottawa, Mycology (DAOM), and Kew (K).

GLOMUS PUSTULATUM Koske, Friese, Walker et Dalpé sp. nov. Figs. 1-3

Sporocarpia ignota. Sporae singulares, flavidae, luteo-brunneae vel aurantiaco-brunneae, globosae ad asymmetricae (43-)86-140 x (60-)

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86-140 µm. Tunica sporae triplici, exteriore flavida, luteo-brunnea vel aurantiaco-brunnea, 1-5 µm crassa usque ad 12 µm crassa propter ciculares usque asymmeticas pustulas; media flavida usque luteo-brunnea lamellosa (3-10 µm crassa); interiore hyalina, membranaceae (<1 µm crassa). Hyphae sustenentes rectae vel recurvae, flavidae usque luteo-brunneae, 6-12 µm crassae. Formans vesicular-arbusculares mycorrhizae.

Sporocarps unknown. *Spores* formed singly in soil on a thin-walled, hyaline coenocytic to sparsely septate subtending hypha (Fig. 1A); pale yellow to yellow-brown or orange-brown, globose to irregular, (43-)86-140 x (60-)86-140 µm. *Spore wall structure* (see murograph, Fig. 3) of three walls (walls 1-3) in one group (group A). Wall 1 a yellow-brown to orange-brown unit wall with a basal thickness of 1-5 µm but thickening up to 12 µm in other regions to produce circular to irregular blister-like areas (up to 38 µm across) on the outer surface (Figs. 1B, E-G, 2A,D). Wall 2 pale yellow to yellow-brown, laminated, 3-10 µm thick (Fig. 1E-F). Wall 3 a thin, hyaline, membranous wall (<1 µm thick) which often is adherent to wall 2 (Fig. 1F), but sometimes separates (Fig. 1C-D). *Subtending hypha* straight or recurved, pale yellow to yellow-brown, continuous with wall 2, 6-12 µm diam at the spore base with walls 0.5-1 µm thick distally. Wall of subtending hypha sometimes slightly thickened at the junction with the spore, but not usually. Wall 1 sometimes continuing distally for up to 37 µm along the subtending hypha. Pore closed by ingrowth of wall 2.

ETYMOLOGY

Latin - *pustulatus* = having pustules; referring to the blister-like structures (pustules) on the surface of the outer spore wall.

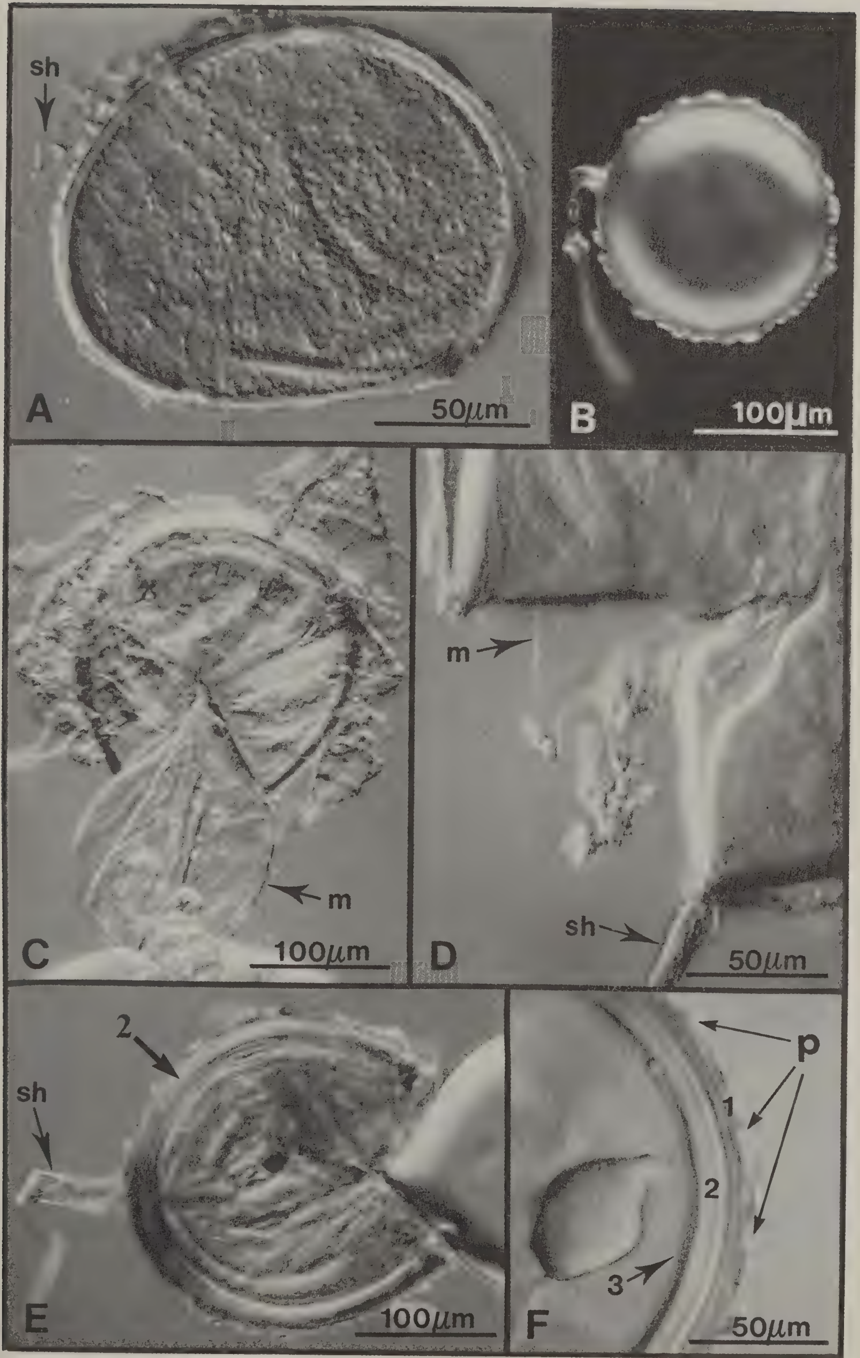
DISTRIBUTION AND HABITAT

The species is known from sand dunes in Rhode Island, U.S.A., and from sandy seashores in Quebec, Canada.

MYCORRHIZAL ASSOCIATIONS

Associated with *Ammophila breviligulata* and *Honkenya peploides*. The fungus formed mycorrhizae with vesicles and arbuscules in pot culture with *Lathyrus maritimus* (Figs. 2B, C,E).

Fig. 1. *Glomus pustulatum*. A. Whole spore with thin-walled subtending hypha ("sh"). B. Whole spore photographed with dark field optics. Note pustules on outer surface. C. Crushed spore with membranous inner wall extruded. D. Crushed spore illustrating membranous wall ("m") and subtending hypha ("sh"). E. Crushed spore. Note thickness of wall 2. F. Wall structure. Note pustules ("p") of wall 1. Wall 3 is very thin.


sh
A
50µm
B
100µm
C
m
100µm
m
sh
D
50µm
2
sh
E
100µm
p
1
2
3
F
50µm

COLLECTIONS EXAMINED: *TYPE*: U.S.A., - Rhode Island, Washington Co., Moonstone Beach, in the root zone of *A. breviligulata*, 11 Jan. 1983 (Walker 1064, Friese 33) OSC, *ISOTYPES*: FH, K. PARATYPES: CANADA, Québec - Baie-Trinité, Pointe-a-Poulin, in root zones of H. *peploides* (Dalpé 906, DAOM 193799) and *L. maritimus* (Dalpé 911, 916, DAOM 193801, 193802) 10 Aug. 1984.

DISCUSSION

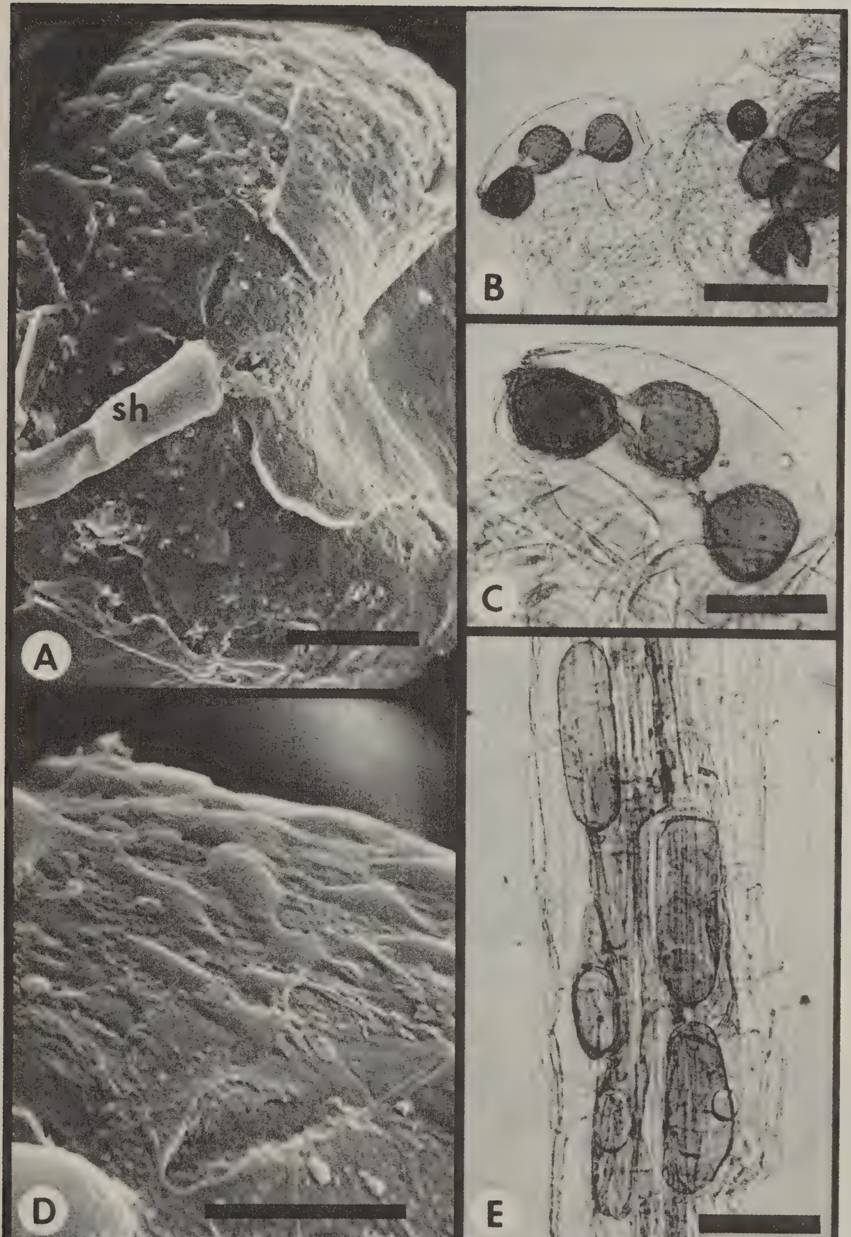
Glomus pustulatum is characterized by the numerous blister-like thickenings on the outermost spore wall (wall 1). These thickenings have the appearance of oil droplets when viewed through a compound microscope. They are not fatty, however, since they remain unstained in Sudan IV. The blister-like areas are circular to irregular in outline, when viewed from directly above but dome shaped in side view (Fig. 1F). The laminations in wall 2 are particularly noticeable in many specimens. Laminae are loose, often separating partially in crushed spores. The innermost laminations are palest in color and may appear almost hyaline. The outer laminations usually are darkest, becoming yellow-brown in some specimens. The membranous wall may be difficult to observe when it is adherent to wall 2, but even under these circumstances, it normally wrinkles a little in the mounting medium. Both the membranous wall and the pustules of wall 1 disappeared almost completely when fresh spores were mounted in 10% KOH or 85% latic acid.

Small spores (48-73 x 60-106 μm) were observed inside nodular tissue of *Lathyrus* (Figs. 2B,C). Cells in nodules containing spores lacked contents and appeared dead.

Spores of *G. pustulatum* are similar to young spores of *G. etunicatum* Becker & Gerd. in color and size (Becker and Gerdemann, 1977). Both species possess an obvious hyaline outer wall, sometimes with a roughened appearance. In *G. etunicatum*, however, the roughening occurs as this evanescent wall is sloughed, whereas wall 1 of *G. pustulatum* is a unit wall that remains intact. In addition, wall 1 of *G. pustulatum* is distinctive, consistently possess the pustules

The outer two walls of *G. gerdemannii* Rose, Daniels & Trappe flake away as amorphous pieces as spores mature.

Fig.2. *Glomus pustulatum*. A. Whole spore showing pustulate surface and subtending hypha ("sh") (S.E.M.), scale bar = 20 μm. B, C. Spores in nodules of 6 mo-old *Lathyrus maritimus* pot culture, scale bar = 200 μm (B), - 100 μm (C). D. Pustulate surface of spores (S.E.M.), scale bar - 10 μm. E. Vesicles in pot cultured *L. maritimus*, scale bar = 100 μm.


A
sh
B
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D
E

Some of these flakes are thin and plate-like, and superficially resemble the projections on spores of G. pustulatum. However, the flakes of G. gerdemannii have jagged edges and are angular rather than smooth and rounded. Some spores of G. clarum Nicol. & Schenck may possess a thin outer wall that can develop cerebriform folds up to 9 µm high (Nicolson & Schenck 1979). The projections on G. pustulatum spores differ from such folds in that they do not arise as wrinkles of the outer wall as it breaks down, but are discrete and permanent.

Despite similarities in the morphology of their outer spore walls, G. gerdemannii and G. clarum are easily separated from G. pustulatum. Spores of the former have a more complex inner wall structure and are large. Spores of the latter never become as dark as those of G. pustulatum and do not have brown or orange as a color component.

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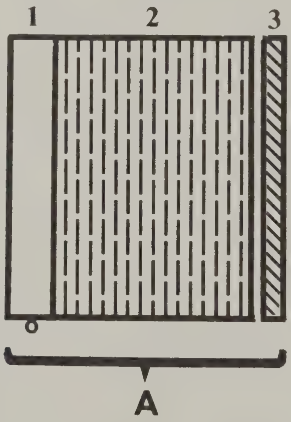

Fig. 3. Murograph of spore wall structure of Glomus pustulatum. See text for explanation. "o" = ornamented (pustules).

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CALONECTRIA SPATHULATA SP. NOV.

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Calonectria spathulata, with its anamorph *Cylindrocladium spathulatum*, is described as a new species from leaf spots on *Eucalyptus viminalis* from Brazil.

Key Words: *Cylindrocladium spathulatum*, *Eucalyptus viminalis*, homothallism.

INTRODUCTION

Species nomenclature of the *Calonectria*/*Cylindrocladium* connection, is based on conidiophore morphology, branching, phialide morphology, conidial morphology and septation, characteristics of a vesicle (if produced) at the apex of the conidiophore and characteristics of the teliomorph, if produced, (ascospore morphology and septation, and anatomy of the perithecial wall).

Recently, species of *Cylindrocladium* are being differentiated on the basis of aminopeptidase profiles (Stevens et al. 1985), and on protein and isoesterase profiles (A. C. Alfenas, Universidade Federal De Vicosa, 36570-Vicosa-MG-Brazil: personal communication).

In September 1983, with the approval of the U. S. Department of Agriculture, Animal and Plant Health Inspection Service, leaves of *Eucalyptus viminalis* Labill., exhibiting discrete leaf spots and variable necrotic lesions, were received for diagnosis from Brazil by the Florida Department of Agriculture and Consumer Services. Isolations from symptomatic leaf tissues yielded Colletotrichum gloeosporioides Penz., a Dothiorella sp., and a Cylindrocladium sp. which closely resembled C. ellipticum Alf., Seymour, and Sob. or C. scoparium Morgan. However, there were subtle but distinct differences between them. Comparative morphological observations of the teleomorphic and anamorphic states were made to determine the identity of the Cylindrocladium isolate, and a technique on the use of isozymes to differentiate between our Brazilian isolate and C. scoparium was performed by Alfenas. As a result, a new species is described herein.

METHODS AND MATERIALS

Initial isolations were made on freshly prepared acidified potato dextrose agar (APDA). The potato dextrose agar (PDA) was prepared from the broth of 200 g freshly peeled, diced, and boiled Irish potatoes supplemented with 20 g dextrose, 1 g KH_2PO_4 and 18 g Difco bacto-agar, and made up to 1 liter with deionized water. Fifteen drops of 50% lactic acid were added to 250 ml of cooled (50 C), autoclaved (121 C for 15 min) PDA to inhibit bacterial growth.

Morphological comparisons were made on subcultures grown on peanut stem water agar (PSWA) which was used to enhance conidial production and promote formation of perithecia. It was prepared in the following manner: cooled, autoclaved water agar was poured over dried, propylene oxide-fumigated (Hansen and Snyder, 1947) stem pieces of peanut (Arachis hypogaea L.). With careful handling, the stem pieces floated and became partially submerged upon solidification of the agar. Single-conidial and single ascospore cultures of the Brazilian isolate were obtained using the method described by Hansen and Smith (1932). Cultures of the Cylindrocladium spp. were grown at 25 ± 2 C under continuous fluorescent light (General Electric F40 LW-RS-WMII at approximately 1000 lux) for 4 weeks or longer on PSWA.

The following live transfers from stored Florida cultures were used in this study: C. ellipticum isolated in 1969 (Log Number 069-952 = Florida Type Culture Collection FTCC 439 = American Type Culture Collection ATCC 38227) from leaves of Mahonia bealei Carr., C. scoparium isolated in 1984 (084-1091) from leaf spots on Callistemon viminalis (Soland. ex Gaertn.) Cheel, C. floridanum Sobers and Seymour isolated in 1980 (080-500 = ATCC 42971) from leaf spots on Rumohra adiantiformis (G. Forst.) Ching, C. floridanum isolated in 1982 (082-2546) from Trifolium pratense L. roots, C. floridanum isolated in 1982 (082-1984) from Malus sylvestris Mill. roots, and C. floridanum first isolated in 1965 (FTCC 394) from Prunus persica (L.) Batsch roots. The type culture of C. floridanum (ATCC 18882) from peach roots was also included in this investigation. These cultures are stored at 12 C in the Department of Agriculture and Consumer Services, Division of Plant Industry, 1911 S. W. 34th Street, Gainesville, Florida 32608, U.S.A.

Perithecia produced on PSWA by the Brazilian isolate were compared to those of Calonectria kyotensis Terashita produced on the same medium by four isolates of C. floridanum mentioned above which had been previously obtained from leaves of leatherleaf fern and roots of red clover, apple, and peach.

A strip of peanut stem epidermis and cortex from PSWA bearing mature perithecia (exuding ascospores) was removed for microtome sectioning. The material was mounted vertically in a drop of 40% mucilage on a cold brass chuck in a -20 C freezing microtome. Sections (14 µm thick) were stained in lactophenol cotton blue. Cells of the perithecial wall were then measured under oil immersion at the equatorial level of longitudinally sectioned ascocarps. Eight ascocarps per isolate were selected at random, and no less than 100 perithecial wall cells per isolate were measured.

TAXONOMY AND DISCUSSION

The Cylindrocladium from E. viminalis has 1- to 3-septate conidia and a single central stipe (an extension of the main axis of the conidiophore stalk) terminating in a spathulate vesicle (Fig. 1), differing from C. ellipticum and C. scoparium which have ellipsoid to oval vesicles and only 1-septate conidia (Alfieri et al., 1970). The isolate under study has doliform phialides. Phialides of C. ellipticum are mostly reniform (Alfieri et al., 1970). Alfenas ran two gels with our isolate from Brazil. He showed that its protein and isoesterase patterns differ from those of C. scoparium (personal communication). The Cylindrocladium under study produced perithecia containing asci and ascospores on PSWA within 3-4 weeks (Fig. 2). Ascospores with up to five septa were extruded from induced perithecia of our Brazilian isolate as compared to the one-septate asco-

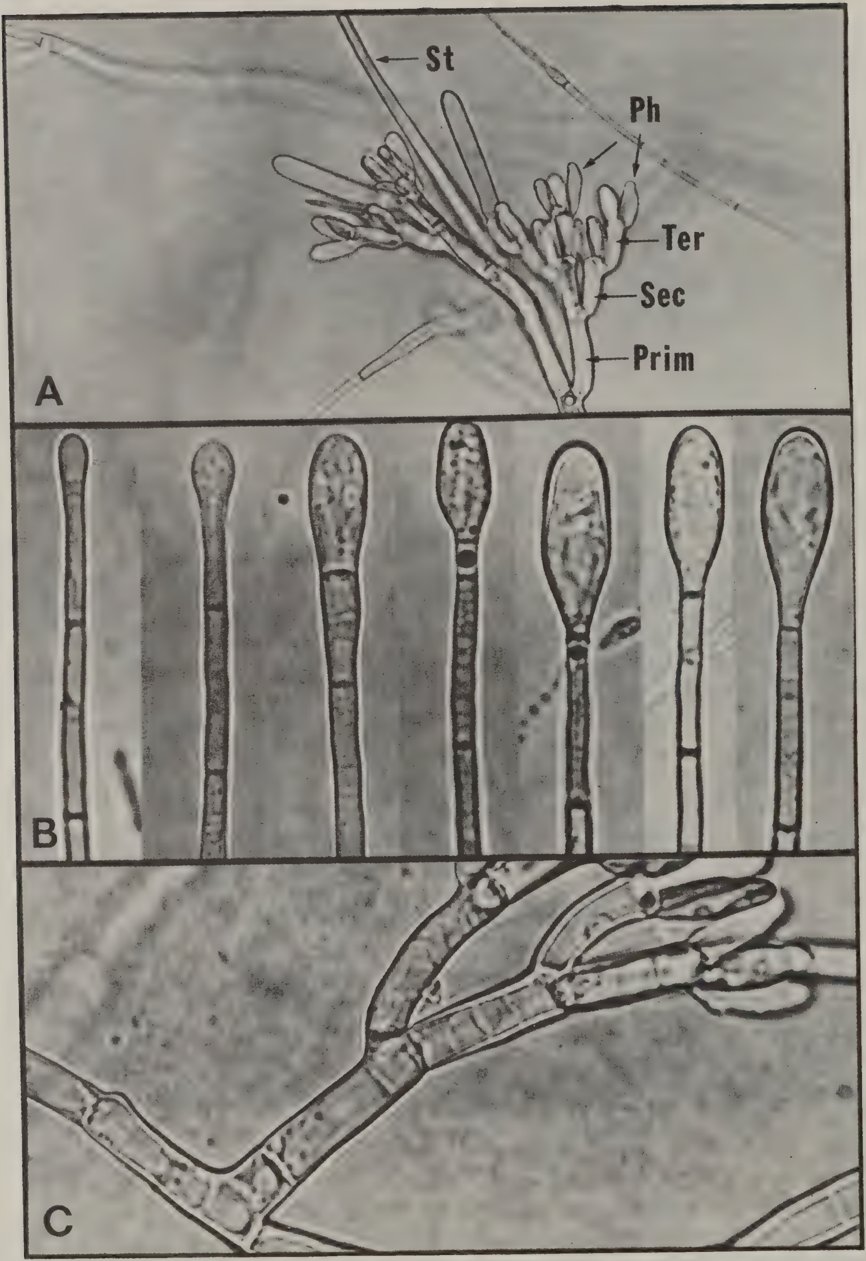

Fig. 1. Cylindrocladium spathulatum: A) Portion of conidiophore showing branching and phialides and a single central stipe, 462 X. (Prim = primary, Sec = secondary, Ter = tertiary, Ph = phialide, St = stipe). B) Stipes and spathulate vesicles, 1155 X. C) Conidophore arising from procumbent mycelial cell, 1155 X.

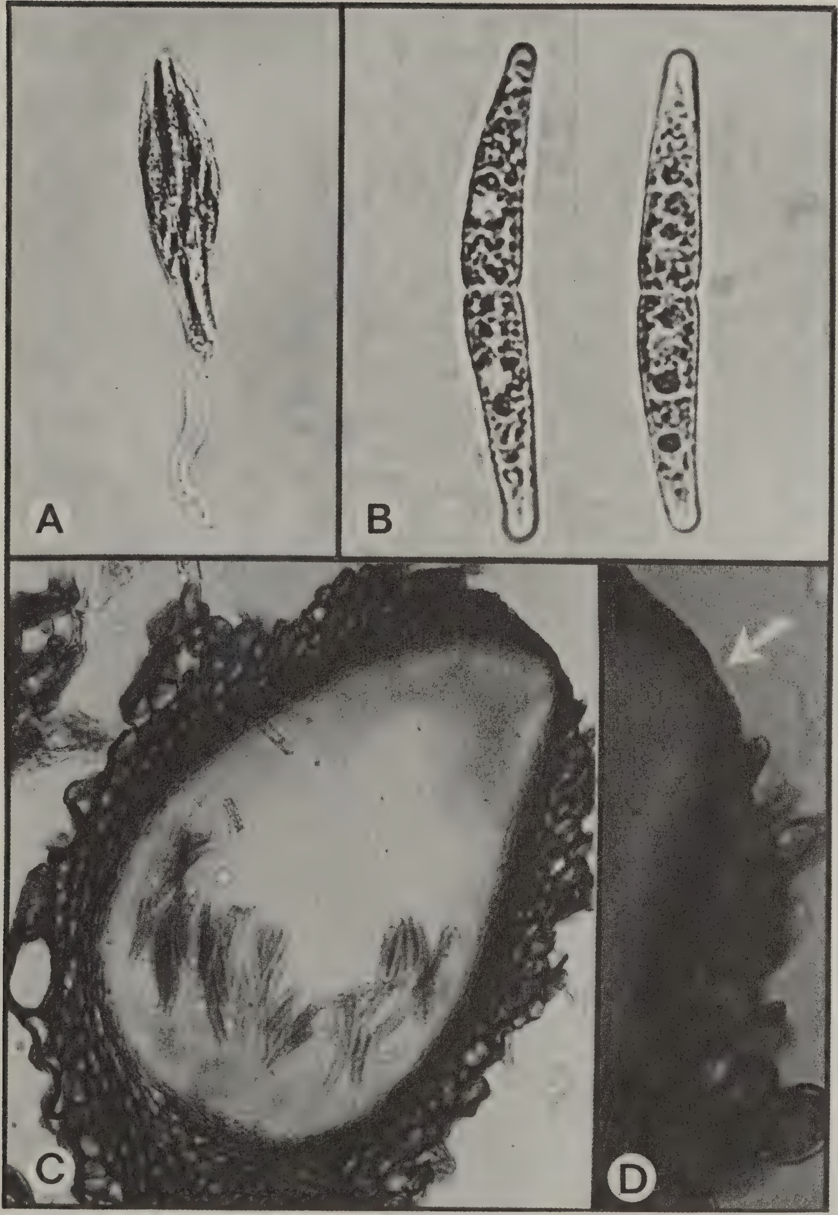

Fig. 2. Calonectria spathulata: A) Ascus containing 8 ascospores, 462 X. B) 1- and 3-septate ascospores showing constriction at the central septum, 1155 X. C) Longitudinal section of an ascocarp showing multiple inner layers of narrow cells. Outer cells oppressed, 231 X. D) close-up of Fig. 2C. Outer cells tapering toward the outside near the ostiole area, 462 X. Ostiole location is indicated by arrow.

spores from induced perithecia of Calonectria kyotensis on PSWA, under the same conditions. Ascospores of C. kyotensis are rarely more than one-septate (Terashita, 1968) and according to Gerlach (1968) they are always one-septate when still in the ascus. Twenty-seven single ascospore cultures from the Brazilian isolate were found to be identical to the culture that produced them. Each culture produced perithecia on PSWA. Forty-one hyphal tips taken from germ tubes of single cells of 24 additional germinating ascospores all developed into self-fertile cultures, clearly establishing the homothallic nature of this fungus. Descriptions were based on the original culture and on six monoascosporic isolates.

Sobers (1973) crossed isolates of C. scoparium from various hosts and locations and obtained orange or yellow perithecia of a Calonectria or a mixture of both colors in approximately equal numbers. Measurements of perithecia, asci, and ascospores were given. Although approximately 85% of the ascospores (which were mostly one-septate) germinated, they soon died and no viable cultures were obtained. Ribeiro (1978) crossed cultures of C. scoparium and obtained perithecia containing asci and ascospores. A new species was then proposed (Calonectria scoparia Ribeiro & Matsuoka sp. nov.), and the heterothallic nature of the fungus was demonstrated. Ascospores (which were mostly one-septate) of this species were pathogenic on detached leaves of Eucalyptus cloeziana F. J. Muell. and seedlings of E. grandis W. Hill ex Maiden under laboratory conditions.

However, Rossman (1983) listed C. scoparium (Fig. 3A & 3B) as the anamorph of Calonectria kyotensis. She further maintains that C. floridanum (Fig. 3C & 3D) is a synonym of C. scoparium and we disagree. We are in agreement with Sobers and Seymour (1967), and Morrison and French (1969), in that C. floridanum and C. scoparium are different and distinct species. Cylindrocladium floridanum is known to have in addition to the central stipe, lateral stipes from secondary conidiophores terminating in sphaeropedunculate (Snell and Dick, 1971) vesicles. We are aware of the variability in vesicle morphology (Hunter and Barnett, 1978), however, vesicle characteristics of all C. floridanum mentioned under Methods and Materials (including the type culture) have been consistently stable on all media used in our studies (APDA, PDA, PSWA), and such characteristics were not observed in C. scoparium. Lateral vesiculate stipes from secondary conidiophores were found in all isolates of C. floridanum included in our studies, but in none of 25 iso-

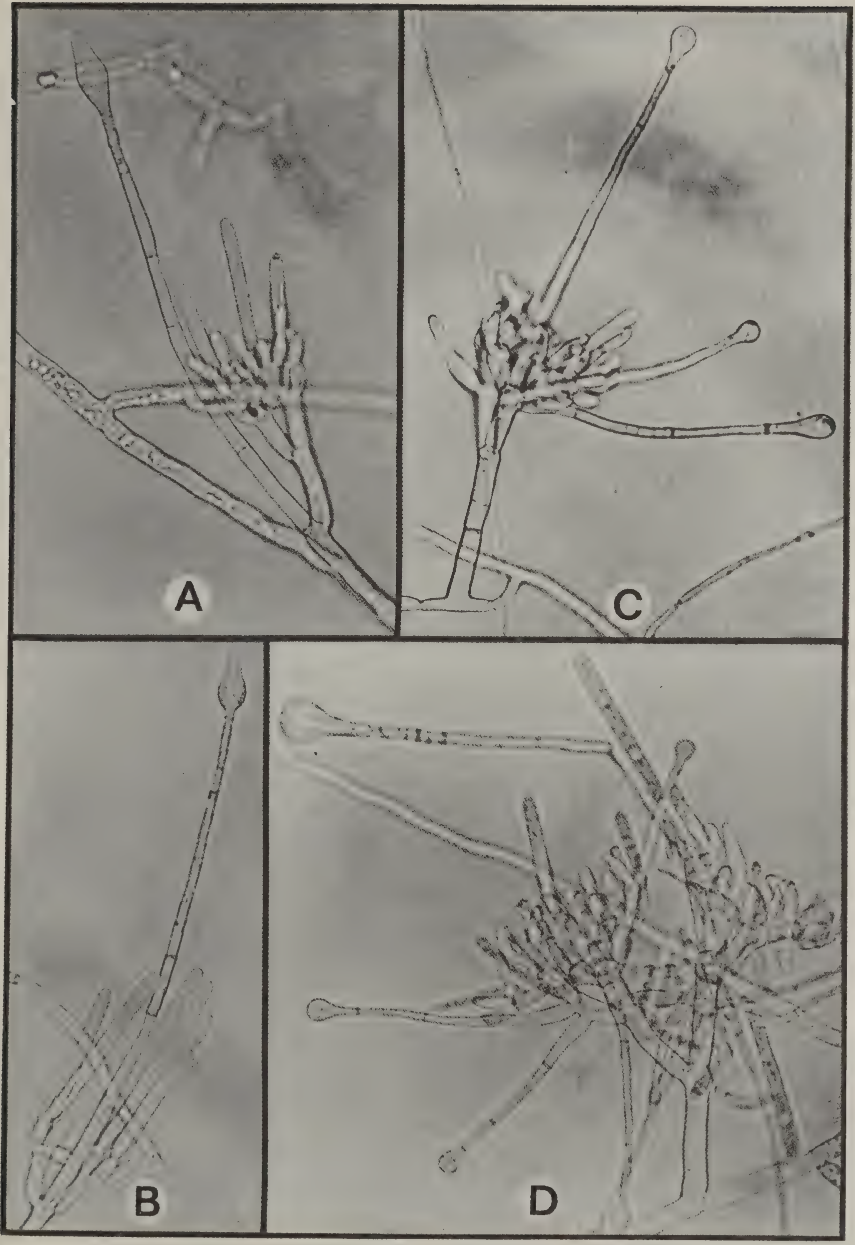

Fig. 3. Cylindrocladium scoparium isolated from Callistemon viminalis leaf spots: A) & B) conidiophores showing a single central stipe terminating in an ellipsoid to oval vesicle, 462 X, and Cylindrocladium floridanum isolated from Rumohra adiantiformis leaf spots: C) & D) conidiophores showing lateral stipes terminating in sphaeropedunculate vesicles, 462 X.

lates of *C. scoparium* collected in Florida and North Carolina.

In 1967, *C. floridanum* was designated as a new species occurring on peach roots in Florida (Sobers and Seymour, 1967), and in 1969, its perfect state was described as *Calonectria floridana* Sob. (Sobers, 1969). In January 1968, *Calonectria kyotensis* Terashita was described with a *Cylindrocladium* conidial state from leaves of *Robinia pseudoacacia* L. and leaves of *Acacia dealbata* Link (Terashita, 1968), and in April 1968, *Calonectria uniseptata* Gerlach was described as the perfect state of *C. scoparium* (Gerlach, 1968). Sobers (1972) later conducted morphological comparisons of the perfect and imperfect states of these three fungi. In addition, he performed comparative pathogenicity tests with these fungi and a known isolate of *C. scoparium*. *Cylindrocladium scoparium* differed from the three isolates under study in that it was slightly virulent to three cultivars of peach roots and highly virulent to roots of three species of *Lupinus*, whereas the three isolates under study were highly virulent to roots of peach and slightly virulent to roots of lupines. The three *Calonectria* isolates revealed only minor differences, which suggested that they were taxonomically identical (Sobers, 1972). Vesicles of the imperfect state of *C. uniseptata* were sphaeropedunculate and typical of *C. floridanum* rather than ellipsoidal as is typical for *C. scoparium*. Sobers (1972) therefore concluded that the imperfect states of the three species of *Calonectria* are *C. floridanum* and that Gerlach (1968) incorrectly identified the imperfect state of *C. uniseptata* as *C. scoparium*. Sobers (1972) also concluded that *C. floridana*, *C. kyotensis* and *C. uniseptata* are synonymous and we concur. Because *C. kyotensis* predates *C. floridana* and *C. uniseptata*, *C. kyotensis* is correctly assigned as the perfect state of *C. floridanum*.

All isolates of *C. floridanum* (including the type culture) mentioned under Methods and Materials, produced *C. kyotensis* perithecia on PSWA under conditions of our study. The anatomy and morphology of all perithecia produced by these isolates were consistently identical. Perithecia produced by the Brazilian isolate (*Calonectria spathulata*) on PSWA, under the same conditions were anatomically and morphologically different as follows:

Calonectria spathulata: the inner layers of longitudinally sectioned perithecial walls are composed of narrow cells. The number of inner layers varies from 3 to 6.

Outer cells are oppressed (less inflated) (Table 1), tapering toward the outside near the ostiole area (Fig. 2C & 2D).

Calonectria kyotensis: 1-4 inner cell layers in the perithecial wall with fewer and larger cells. Outer cells are more inflated. (Table 1). These characteristics are consistent among isolates which were derived from different hosts (Fig. 4).

Based on characteristics of the anamorphic and teleomorphic states of these fungi, on the difference in protein and isoesterase patterns, and on the basis of the differences noted as outlined in Table 1, this isolate from Brazil is considered anatomically, morphologically, and physiologically distinct from previously described species in this genus, and we propose the following new species:

Calonectria spathulata El-Gholl, Kimbrough, Barnard, Alfieri, et Schoulties, sp. nov.

Perithecia lutea vel rufa, globosa vel subglobosa (318-) 422 (-536) μm alta x (273-) 367 (-457) μm lata, muro exteriore aspere verrucoso. Perithecia superficialia singulatim portata vel in globulis et ostiolo papillato. Asci hyalini, (87-) 128 (-162) x (10-) 18 (-24) μm. Ascosporae hyalini, granulares, recti vel falcati, plurimi 1-septati, in medio septo constricti, (14.0-) 40.0 (-70.0) x (3.2-) 5.3 (-7.4) μm, et (30.0-) 48.0 (-64.0) x (4.0-) 5.3 (-7.4) μm, et (36.0-) 48.0 (-76.0) x (3.0-) 5.3 (-6.9) μm, singulis 1-, 2-, et 3-septatis ascosporis. Ascosporae 4 et 5 septorum raro visae.

Habitat: Secreta ex maculis folii in Eucalypto viminali; perithecia in partibus stirpis Arachis hypogaea.

Locus typi: Santa Catarina, Brazilia.

Holotypus: Teleomorphosis FLAS F54257, anamorphosis FTCC 1001, September 1983.

Cylindrocladium spathulatum El-Gholl, Kimbrough, Barnard, Alfieri, et Schoulties anam. nov.

Conidiophora lateraliter portata uno medio stipite qui vesicula hyalina et spathulata terminatur (11.0-) 20.0 (-38.0) x (3.5-) 7.0 (-12.0) μm. Stipites recte orientes ex myceliis procumbentibus in cultura. Stipites septati, (4.5-) 6.0 (-6.9) μm ad basim lati, angustiores (2.5-) 2.9 (-3.2)

Table 1. Measurements of inner and outer cells of longitudinally sectioned ascocarp periderms.

SPECIES	HOSTS	INNER CELLS[1]		OUTER CELLS	
		LENGTH(μm)	WIDTH(μm)	LENGTH(μm)	WIDTH(μm)
Calonectria spathulata	*Eucalyptus viminalis*	(5.9-)12.9(-26.7)	(1.0-)2.6(-4.0)	(5.0-)13.8(-32.7)	(4.0-)10.5(-26.7)
Calonectria kyotensis	*Malus sylvestris*	(6.9-)16.9(-27.7)	(2.5-)4.3(-6.4)	(6.9-)22.5(-41.6)	(5.0-)14.1(-30.7)
	Rumohra adiantiformis	(5.0-)15.6(-28.7)	(3.0-)5.0(-6.9)	(8.9-)18.9(-29.7)	(5.0-)13.9(-27.7)
	Trifolium pratense	(9.9-)18.7(-33.7)	(3.0-)5.0(-6.9)	(8.9-)23.8(-51.5)	(5.0-)14.9(-29.7)

[1] 3-6 inner cell layers in *C. spathulata*
1-4 inner cell layers in *C. kyotensis*

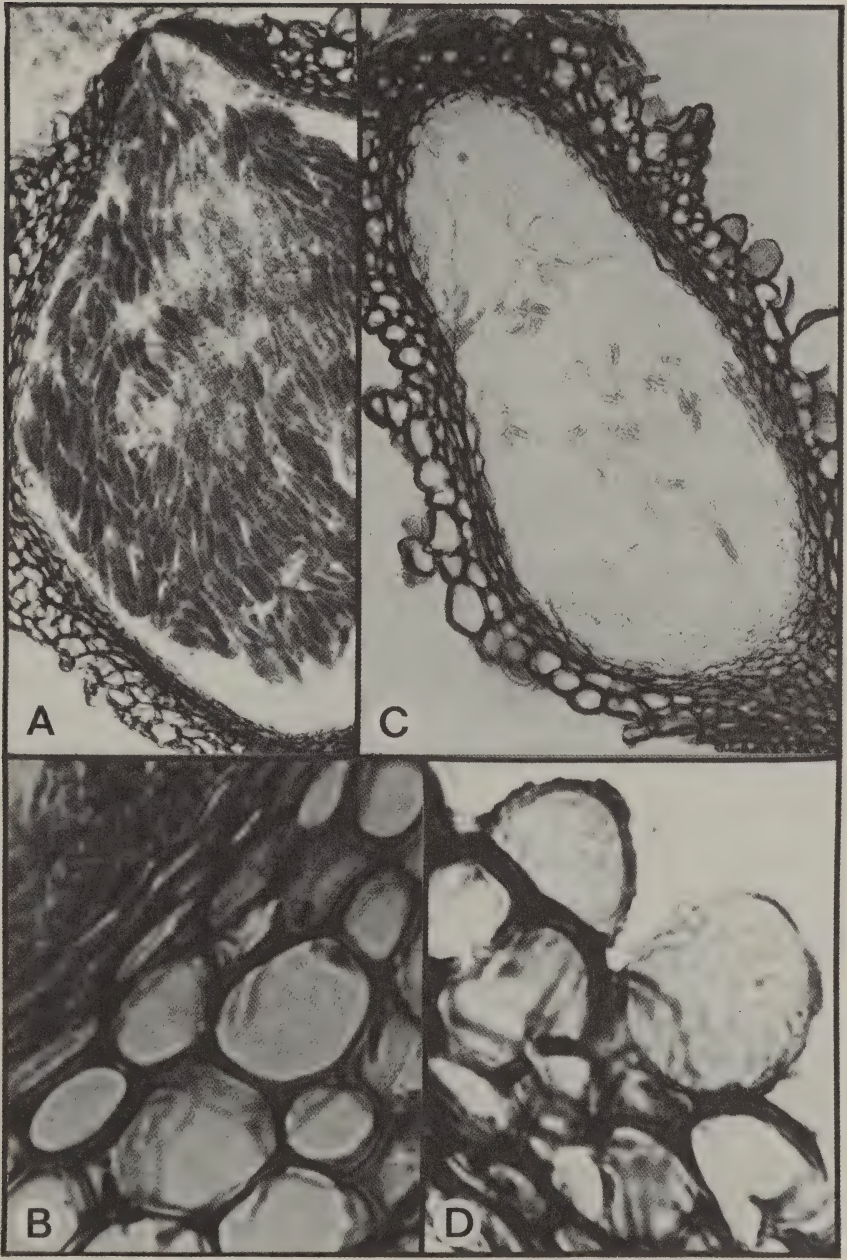

Fig. 4. Calonectria kyotensis from: Trifolium pratense A) & B) and Rumohra adiantiformis C) & D). A) Longitudinal section of an ascocarp showing few inner layers of large cells and inflated outer cells, 231 X. B) Longitudinal section at the equatorial level showing a close-up of inflated cells, 1,155 X. C) Same characteristics as in Fig. 4A, 231 X. D) Same as in Fig.4B, 1,155 X.

µm ad basim vesiculi facta, (172-) 202 (-231) µm cum vesiculo longi. Plurimi primarii rami conidiophori nonseptati (14-) 28 (-52) µm. Plurimi secundarii rami conidiophori nonseptati (13.0-) 15.5 (-20.0) µm. Duo vel tres vel quattuor phialides ex termino alicuius rami oriri possunt. Phialides hyalinae, nonseptatae, doliformam habentes, (9.0-) 13.0 (-17.0) x (4.0-) 4.8 (-6.4) µm. Conidia ex apice phialidum formata. Conidia hyalina, cylindrata, recta, granularia, ad ambos terminos rotunda, (39.0-) 58.0 (-78.0) x (4.0-) 5.1 (-6.0) µm, et (54.0-) 66.0 (-84.0) x (4.5-) 5.5 (-5.9) µm, et (55.0-) 68.0 (-86.0) x (5.0-) 5.6 (-6.0) µm singulis 1-, 2-, et 3-septatis conidiis.

Habitat: Secreta ex maculis folii in Eucalypto viminali.

Locus typi: Santa Catarina, Brazilia.

Calonectria spathulata El-Gholl, Kimbrough, Barnard, Alfieri, & Schoulties sp. nov.

Perithecia orange-red, globose or subglobose, (318-) 422 (-536) µm high by (273-) 367 (-457) µm wide, with rough warted outer wall. Perithecia superficial, borne singly or in small groups and with a papillate ostiolum. Asci hyaline, (87-) 128 (-162) x (10-) 18 (-24) µm, containing 4-8 ascospores. Ascospores hyaline, granular, straight to falcate, mostly 1-septate, constricted at the central septum, (14.0-) 40.0 (-71.0) x (3.2-) 5.3 (-7.4) µm, (30.0-) 48.0 (-64.0) x (4.0-) 5.3 (-7.4) µm, and (36.0-) 48.0 (-76.0) x (3.0-) 5.3 (-6.9) µm for the 1-, 2-, and 3-septate ascospores, respectively. Ascospores with 4 and 5 septa rarely observed.

Habitat: Isolated from leaf spots on Eucalyptus viminalis; perithecia induced on Arachis hypogaea stem pieces.

Type locality: Santa Catarina, Brazil.

Holotype: Teleomorphosis FLAS F54257, anamorphosis FTCC 1001, September 1983.

Cylindrocladium spathulatum El-Gholl, Kimbrough, Barnard, Alfieri, and Schoulties anam. nov.

Conidiophores borne laterally on a single central stipe that terminates in a hyaline, spathulate vesicle (11.0-) 20.0 (-38.0) x (3.5-) 7.0 (-12.0) µm. Stipes arising at right angles from procumbent mycelia in culture. Stipes

septate, (4.5-) 6.0 (-6.9) µm wide at the base, becoming narrower (2.5-) 2.9 (-3.2) µm at the base of the vesicle, (172-) 202 (-231) µm long including the vesicle. Primary conidiophore branches mostly nonseptate, (14-) 28 (-52) µm. Secondary conidiophore branches mostly nonseptate, (13.0-) 15.5 (-20.0)µm. Tertiary conidiophore branches nonseptate and seldom observed. Two to four phialides may develop from the terminal end of any of the branches. Phialides hyaline, nonseptate, doliform, (9.0-) 13.0 (-17.0) x (4.0-) 4.8 (-6.4) µm. Conidia formed from the apex of the phialides. Conidia hyaline, cylindrical, straight, granular, rounded at both ends, (39.0-) 58.0 (-78.0) x (4.0-) 5.1 (-6.0) µm, (54.0-) 66.0 (-84.0) x (4.5-) 5.5 (-5.9) µm and (55.0-) 68.0 (-86.0) x (5.0-) 5.6 (-6.0) µm for the 1-, 2-, and 3-septate conidia, respectively.

Habitat: Isolated from leaf spots on Eucalyptus viminalis.

Type locality: Santa Catarina, Brazil.

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MYCORRHIZAL SYNTHESIS OF AMANITA MUSCARIA VAR. PERSICINA WITH HARD PINES

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ABSTRACT

Amanita muscaria var. *persicina* Jenkins synthesized ectomycorrhizae with *Pinus taeda* L. and *P. virginiana* Mill. under laboratory conditions. Normal monopodial and bifurcate mantles formed on short roots and a well developed hartig net was present. The fungus was reisolated from the mantles and its identity verified by its cultural characteristics.

INTRODUCTION

Ectomycorrhizal relationships among forest trees and Homobasidiomycetes have often been postulated on the basis of field observations (Trappe, 1962; Malloch & Malloch, 1981). Based upon field observations of fungus-host relationships, we have tested a wide spectrum of potential hosts and their postulated symbionts. Molina and Trappe (1982), Molina (1980) and many others including researchers at our laboratory have synthesized large numbers of mycorrhizae with known fungus-host relationships. These studies made it possible for Miller (1982) to postulate which families of the Agaricales were mycorrhizal and to point out the systematic relationships of those which evolved as decomposers. The Amanitaceae is one of those families of the Agaricales in which the species are either suspected or known ectomycorrhizal symbionts of the Pinaceae in the Coniferales and several families of Angiosperms.

Many of the species of *Amanita* are found associated with specific plants or plant communities. However, *Amanita muscaria* (L.: Fr.) Hooker is found in natural forests throughout the Northern Hemisphere and in Southern Hemisphere countries such as Australia where it fruits under exotic trees such as *Quercus* and *Pinus* (Cleland, 1934). *Amanita muscaria* was first synthesized as an ectomycorrhizal symbiont of *Pinus sylvestris* L. by Melin (1923) and again in 1925 with larch (*Larix decidua* Mill.) by Melin. Wilcox (1971) presented detailed evidence of the formation of both mantle and hartig net with *P. resinosa* Ait.. Its world wide distribution seems to indicate a broad host range. Recently experimental proof of this versatility was established in a paper by Read and Finlay (1984). Their study was carried out through the synthesis of interplant mycorrhizal colonization of four conifers in two genera, *Pinus* and *Picea* and one Angiosperm (*Betula glandulosa* Michx.). The tester strain of *A. muscaria* synthesized mycorrhizae with all four hosts.

Within the genus *Amanita*, *muscaria* is a well defined species characterized in a full description by Jenkins (in press). The concept of the species *muscaria*, however, includes several phenotypically recognizable varieties. It is the objective of this study to begin the process of synthesizing the variants of *A. muscaria*. *Amanita muscaria* var. *persicina* Jenkins, the variety with which we worked, has a yellowish-orange pileus, volval remnants which are yellowish to tannish, and a white to tannish-white stipe which becomes yellowish upon bruising. In addition, the volval remnants on the stipe base and bulb usually remain as flocculence or randomly distributed patches but rarely as irregular ringlets.

In an unpublished study comparing the cultural characteristics among five varieties of A. muscaria, the variety persicina grew much faster on Hagem's medium than did the other four varieties. A similar result was obtained with Malt Extract Agar. The reason for this nonconformity, however, has not been determined.

Some populations of A. muscaria also have toxic isoxzole derivatives. According to Lincoff and Mitchel (1977) many people believed that only the red pileate form contained toxins. However, Benedict, Tyler, and Brady (1966) found that isoxazole yields from the white, orange and red varieties of A. muscaria are all comparable and occur independently of pileus coloration. Similar concentrations of toxins have been determined for var. persicina by Dr. Scott Chilton (pers. comm.).

The phenotypic variability of this species suggests that some varieties may be mycorrhizal with one or a limited number of hosts and may even have a modicum of geographic separation. Fruitings of A. muscaria var. persicina have been observed to be associated with Pinus taeda.

METHODS

Seeds of Pinus taeda and our standard test tree, P. virginiana were germinated in petri dishes on water agar after surface sterilization with 30% hydrogen peroxide for 45 minutes. Large screw cap test tubes (40 X 250 mm) were filled with 110 cm of vermiculite and 10 cm of sifted peat, and moistened with 75 mls modified Hagem's solution containing .05 mg biotin and 1.0 g thiamin per liter. Mycorrhizal fungi were grown out for 28 days in test tubes containing 10 mls Hagem's to which glass chips were added. During this period the tubes were shaken every third day to fragment the mycelium. At the end of this time, the fungi were poured into the large tubes and allowed to colonize the peat/vermiculite mixture for 14 days. The young seedlings were transferred to the large tubes 14 days after the introduction of the fungus, when their radicle was 2-3 cm long. Following a period of growth (usually 8-16 weeks) the tree was removed, washed and examined for mycorrhizae. The texture, color, and macroscopic appearance of the mantles were recorded and some samples fixed and embedded for microscopic study. Fresh root tips were aseptically removed and placed on Hagem's agar to recover the symbiont.

Suspected mycorrhizal rootlets were removed using a razor blade and forceps, fixed for at least 24 hours in FAA, dehydrated through ethanol to tert-butyl alcohol and infiltrated using parafin oil and Paraplast. Sections were cut at 10 um using an AO microtome blade on an AO Spencer "820" microtome. Sections were stained with safranin O and counter-stained with fast green. Cover slips were permanently mounted using Permount mounting medium.

Two isolates provided by Dr. Jenkins, 1656 and 1610, were used in the experiments. Six tubes were inoculated for each isolate. Two tubes of each isolate became contaminated leaving four replicates for each culture. Contaminate free seedlings were grown in the remaining tubes. The root systems were then removed from the tubes and examined for the presence of ectomycorrhizal mantles.

RESULTS

Isolate 1656 grew well throughout the tubes but no mycorrhizal synthesis took place. However, isolate 1610 formed healthy appearing, monopodial and bifurcate ectomycorrhizae with both *Pinus taeda* (Figs. 1 & 2) and *P. virginiana* (Figs. 3 & 4). A thick mantle indicated by the arrows in Fig. 1 was accompanied by a well developed Hartig net shown in Figs. 2-4. Chlamydospores are evident in the mantle, as indicated in Fig. 4. Upon reisolation from the culture tubes both isolates exhibited a dense, fluffy white mat of mycelium initially, and shortly thereafter stabilized with characteristic growth which will be described in a later paper. Growth was much more rapid in both of the reisolated cultures than in the initial cultures.

Pinus taeda (Figs. 1 & 2) hartig net formation is well developed and appears normal in every way. Populations of *A. muscaria* var. *persicina* are normally found associated with *P. taeda* in nature. Our test tree, *P. virginiana* also formed a well developed hartig net (Figs. 3 & 4) and appears equally healthy but has not been associated with var. *persicina* in nature. Further testing with other pines is being carried out to determine the host range of this variety of *A. muscaria*.

Chlamydospores are routinely formed in the mantle as shown in Fig. 4. Cultures of the other varieties must be studied and described to determine if the chlamydospores are a feature of the entire species or only certain varieties.

ACKNOWLEDGMENTS

The authors would like to thank Dr. John Palmer and Dr. Harold Burdsall for their comments on the manuscript and the help of Hope H. Miller in editing and typing.

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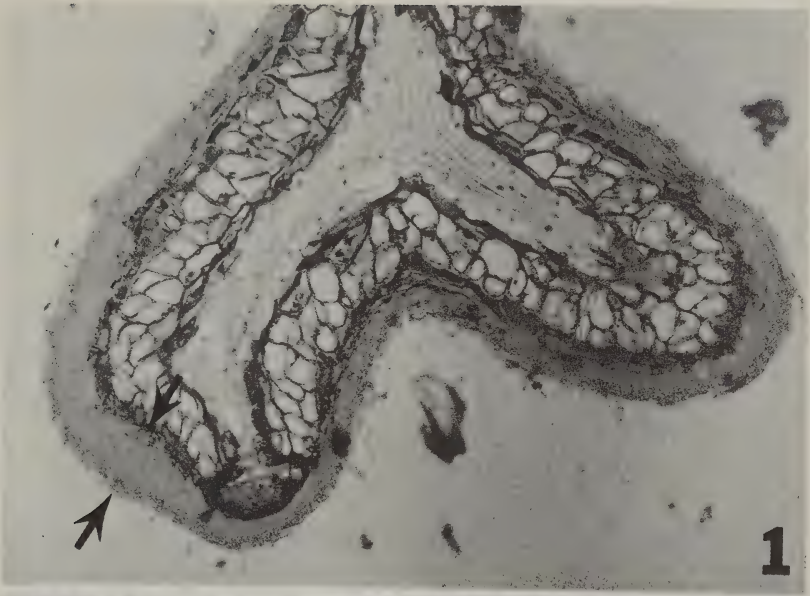
EXPLANATION OF PLATES

Figs. 1 & 2. Pinus taeda mycorrhizal rootlets in longitudinal section. 1. ectomycorrhizal sheath (see arrows) covering a bifurcate rootlet (X 250). 2. mantle on right with a hartig net visible among the cortical cells (X 1000).

Figs. 3 & 4. Pinus virginiana mycorrhizal rootlets in cross section. 3. ectomycorrhizal mantle with a well developed hartig net (X 400). 4. mantle on right with hartig net and chlamydospore indicated by the arrows (X 1000).



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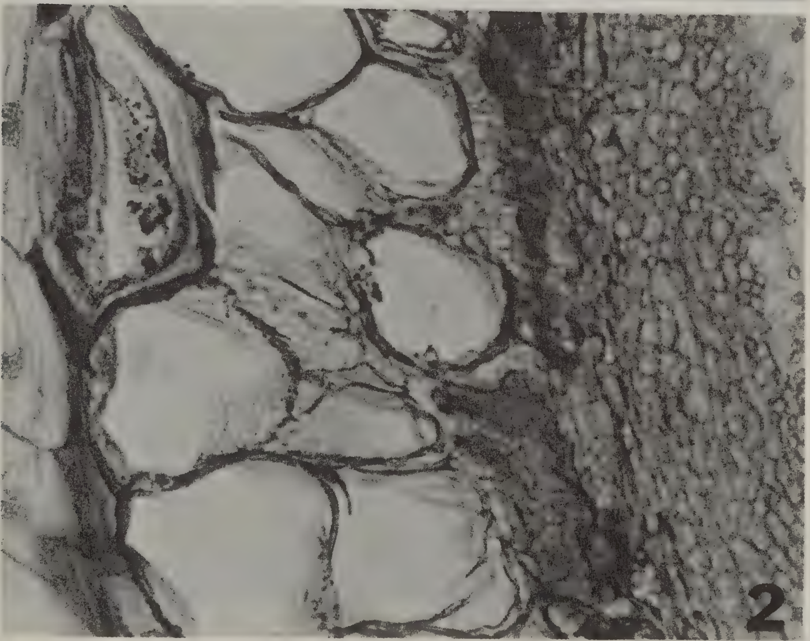

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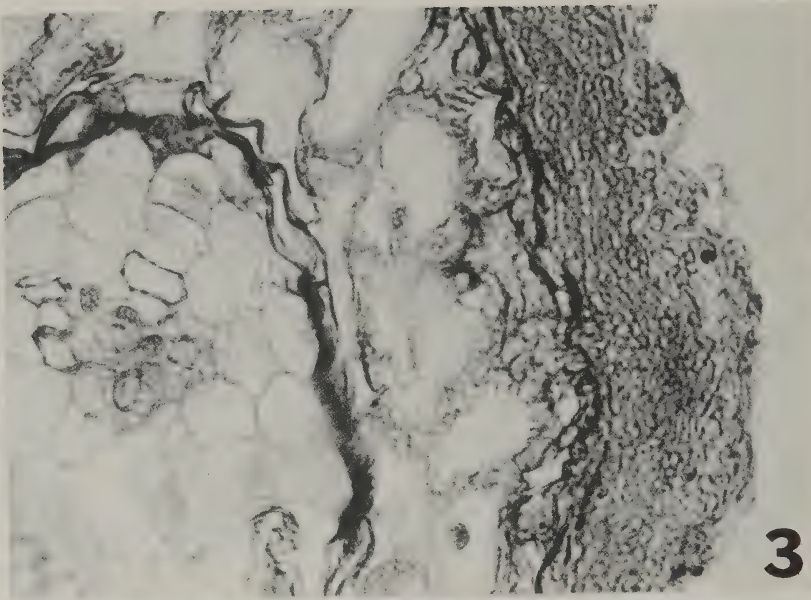

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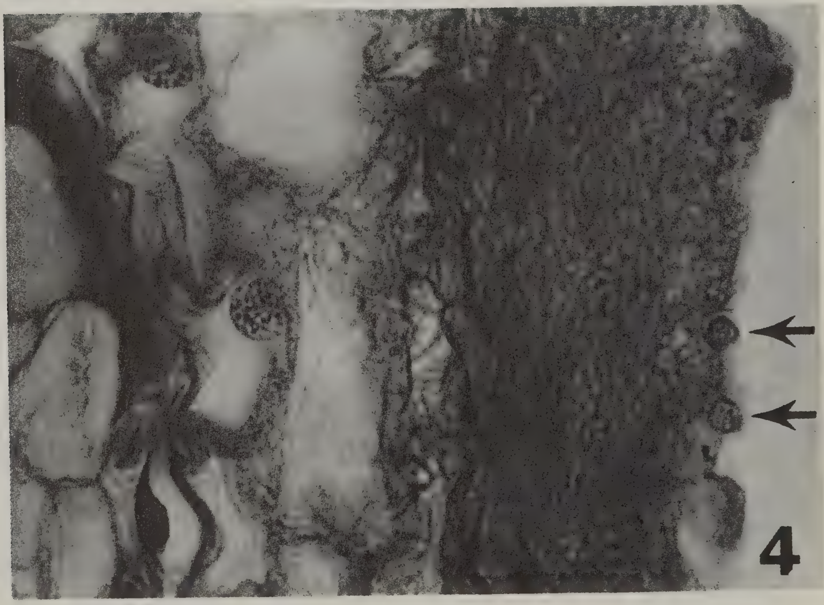

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NEW OR INTERESTING GREENLAND LICHENS III

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SUMMARY

148 specimens of 20 species of Greenland lichens have been revised and re-identified. Seven of the species, viz. Aspicilia sanguinea Krempelh., Lecidea atrofulva Sommerf., L. insularis Nyl., Rinodina mucronatula H.Magn., R. soredicola Degel., Verrucaria degelii R.Sant. and V. praetermissa (Trevis.) Anzi, are new to Greenland. Seven species, viz. Acarospora sinopica (Wahlenb.) Körb., Candelariella arctica (Körb.) R.Sant., Cetraria andrejevii Oxner, Huilia flavocaerulescens (Hornem.) Hertel, Lecanora cenisia Ach., Lecidea silacea (Ach.) Ach. and Phylliscum demangeonii (Moug. & Mont. in Mont.) Nyl. are new to E. Greenland (Acarospora sinopica is new to C.W. Greenland, too). Three species, viz. Acarospora schleicheri (Ach.) Massal., Aspicilia caesiocinerea (Nyl. ex Malbr.) Arn. and Polyblastia sendtneri Krempelh. are new to W. Greenland. Two species are new to S.E. Greenland, viz. Aspicilia verrucigera Hue and Cladonia luteoalba A. Wils. & Wheld. Ochrolechia grimmiae Lynge appears to be a more common species in S.E. Greenland than previously supposed.

INTRODUCTION

In this paper the reports on the occurrence in Greenland of lichens that are of particular taxonomical and phytogeographical interest are continued. It is mainly the result of the revisions and identifications of the comprehensive collections of Dr. Paul Gelting, but the paper also deals with selected parts of quite recent collections of Greenland lichens, viz. those of V. Alstrup (middle of the seventies), J. Poelt & H. Ullrich (1982 and 1983) and the present author (1985).

LIST OF SPECIES

ACAROSPORA SCHLEICHERI (Ach.) Massal. - C.W. Greenland: Søndre Strømfjord, Angujartorfiup nuna, Arnangarngup kua, c. 66°30'N c. 51°15'W, 100 m, on soil together with, e.g. *Psora rubiformis*; one specimen, leg. V. Alstrup. - Søndre Strømfjord, 67°01'N 50°43'W, on loess on steppe-like slope above the airport; two specimens, leg. J. Poelt & E. Steen Hansen, respectively. - N.E. Greenland: Hudson Land, site at the east side of Øvre Stordal, 73°51'N 22°27'W, 800 m, on soil in stable scree; one specimen, leg. R.W.M. Corner, det. the present author.

All of the specimens are richly fertile. A. schleicheri is new to W. Greenland. It has previously been reported from a few localities around the great inlet systems in C.E. Greenland (E.S.Hansen 1982). This circumpolar species is usually associated with dry steppe soils (Thomson 1979).

ACAROSPORA SINOPICA (Wahlenb.) Körb. - S.W. Greenland: Igdlutalik, Karra, 60°51'N 46°09'W, 1-4 m, on dyke; one specimen, leg. V.Alstrup. - Site west of Agpat, 60°56'N 45°49'W, 100 m, on N.-exposed naujaite; one specimen, leg. V. Alstrup. - Godthåbsfjord, Ilulialik, Eqaluit, 64°50'N 50°36'W, 30 m, on siliceous rock; one specimen, leg. V. Alstrup. - Sdr. Isortoq, Nuk, 65°30'N 52°09'W, 250 m, on basaltic rock; one specimen, leg. V. Alstrup. - C.W. Greenland: E. Disko, Qutdligssat, 70°05'N 53°01'W, 20 m, on somewhat shady faces of basaltic bird rock and dyke rich in iron in old coal mine; two specimens, leg. P. Gelting. - S.E. Greenland: Angmagssalik, 65°36'N 37°38'W, on norite especially rich in iron minerals together with, e.g. *Lecidea silacea*, *Huilia melinodes* and *Tremolecia atrata*; four specimens, leg. E. Steen Hansen.

A.H. Magnusson (1935) reported on A. sinopica from Holsteinsborg, Nanortalik and Okivisekan, but the additional specimens mentioned here indicate that the species has a wider distribution in Greenland than previously supposed. The plants collected at Qutdligssat agree with those from Holsteinsborg having a contiguous areolate thallus with distinct radiate lobes. Such lobes are lacking by the remaining specimens, which have either scattered, rounded areoles (that can be slightly lobate) or a more or less areolate thallus without radiate lobes. Punctiform to larger apothecia with reddish brown disc are usually present. The colour of the thallus is deep rust-red contrary to *Acarospora smaragdula* (Wahlenb. in Ach.) Massal. var *lesdainii* (Harm. ex A.L. Sm.) H. Magn. that have a dark brown thallus. While the last taxon is often found growing on overhanging rocks (Santesson 1984), A. sinopica has a preference for more exposed rocks.

A. sinopica is widely distributed in alpine and northern regions of the northern hemisphere (Ozenda & Clauzade 1970). It is new to C.W. and E. Greenland.

ASPICILIA CAESIOCINEREA (Nyl. ex Malbr.) Arn. (Syn. Lecanora c. Nyl. ex Malbr.) - C.W. Greenland: S. Disko, Godhavn, Østerdalen, 69°15'N 53°33'W, 20 m, on gneissic rock together with Lecidea lactea, L. atrobrunnea and Umbilicaria torrefacta; one specimen, leg. P. Gelting. - S. Disko, Blåfjeld, Nuk kitleq, 69°22'N 54°15'W, 20 m, on basaltic rock manured by birds, growing together with Candelariella vitellina; one specimen, leg. P. Gelting. - W. Disko, Mellemfjord, Sarqardlît silardlit, 69°47'N 54°44'W, 6 m, on basaltic boulder; one specimen, leg. P. Gelting. - S.E. Greenland: Angmagssalik, 65°36'N 37°38'W, on the top of manured boulder composed of norite; one specimen, leg. E. Steen Hansen.

Thallus of the present plant is very thick, which often applies to lichens occurring on rocks that are moderately to strongly influenced by guano. It is, however, distinctly areolate with angular, scabrid, bluish grey areoles, in which the apothecia are immersed.

A. caesiocinerea is new to W. Greenland. It has previously been reported from E. Greenland by Daniëls (1975), who found it to be an occasional member of epilithic lichen communities dominated by Xanthoria elegans. The distribution of A. caesiocinerea is probably circumpolar, arctic-alpine (Thomson 1979).

ASPICILIA SANGUINEA Krempelh. (Syn. Lecanora s. (Krempelh.) Migula - C.W. Greenland: Diskofjord, eastern coast of Storø (Qeqertaq), 69°31'N 54°06'W, on basaltic boulder in brook; one specimen, leg P. Gelting.

This specimen mainly consists of densely grouped apothecia that are surrounded by a slightly raised margin. The disc of the apothecia is liver-coloured. It becomes blood-red in contact with water. The spores measure 17-20 x 10-12 µm. Thallus is grey with a reddish tinge.

A. sanguinea is distributed mainly in boreal and arctic-alpine areas of Europe and North America (Ozenda & Clauzade 1970; Santesson 1984). It is new to Greenland.

ASPICILIA VERRUCIGERA Hue (Syn. Lecanora v. (Hue) Zahlbr. - C.W. Greenland: Disko, Godhavn, 69°15'N 53°32'W, 12 m, on ± manured gneissic rock; one specimen, leg P. Gelting, det. A.H. Magnusson.

Thallus of the present plant reacts K+ yellow. Apothecia are abundant.

A. verrucigera has a scattered occurrence in alpine areas of Europe. It is new to Greenland.

CANDELARIELLA ARCTICA (Körb.) R. Sant. (Syn. C. crenulata (Wahlenb.) Zahlbr. - C.W. Greenland: Disko Bay, N. Brændevinsskær (Asigsut), 69°04'N 53°31'W, on gneissic rocks together with Lecanora straminea; two specimens, leg. P. Gelting. - S. Disko, Fortunebay, Qeqertarssuk, 69°16'N 53°46'W, 4-6 m, on E.- and W.-exposed faces of gneissic rock below nesting site of Larus glaucoides; two specimens, leg. P. Gelting.

The above specimens are distinctly radiate, the lobes to 3 mm long and 1 mm broad and somewhat branched. Apothecia occur abundantly; the margin is concolourous with the thallus (yolk coloured), the disc is yellowish brown. Spores are numerous.

The present collections of C. arctica constitute a northern extension of its known distribution range in W. Greenland. It has a rather frequent occurrence farther southwards on the west coast with a distinct preference for seashore rocks manured by birds (Lynge 1937, Alstrup 1977), but has so far not been found in East Greenland.

CETRARIA ANDREJEVII Oxner - S.E. Greenland: Lindenows Fjord, Narssaq, 60°30'N 43°25'W (Dahl, Lynge & Scholander 1937); one specimen, leg. P.F. Scholander (who first referred it to C. islandica), det. I. Kärnefelt. - C.E. Greenland: Scoresby Land, Mesters Vig, c. 72°08'N 23°50'W, in heath somewhat east of the airstrip; one specimen, leg. R.W.M. Corner, det. the present author.

Thallus of the specimen from S.E. Greenland is up to 5 cm high. The lobes are up to 15 mm broad, canaliculate. Upper parts of the lobes are chestnut-brown, somewhat shiny, basal parts are pale brown, dull. Distinct ridges and wrinkles are lacking. The specimen collected by Corner has a quite different appearance: the upper part of the lobes is canaliculate, while the lower part is more or less flat, up to 1 cm broad and distinctly wrinkled. The colour of the lobes are much lighter than that of the specimen from S.E. Greenland (cf. Cetraria simmonsii Krog).

C. andrejevii has a wide amphi-Beringian distribution (Kärnefelt 1979). It is new to E. Greenland. The South East Greenland plants presumably have been dispersed from populations in S.W. Greenland. It is difficult to explain the single isolated occurrence of C. andrejevii in Scoresby Land in C.E. Greenland.

CLADONIA LUTEOALBA A. Wils. & Wheld. - S.E. Greenland: Angmagssalik, 65°36'N 37°38'W, on soil rich in humus in snowbed together with, e.g. *Solorina crocea*; one specimen, leg. E. Steen Hansen.

The specimen agrees well with the previous Greenland collections of C. luteoalba, consisting only of the very characteristic basal squamules with the yellow, arachnoid underside exposed (Alstrup 1979; E.S. Hansen 1982).

The distribution of C. luteoalba is probably circumpolar. It is new to S.E. Greenland.

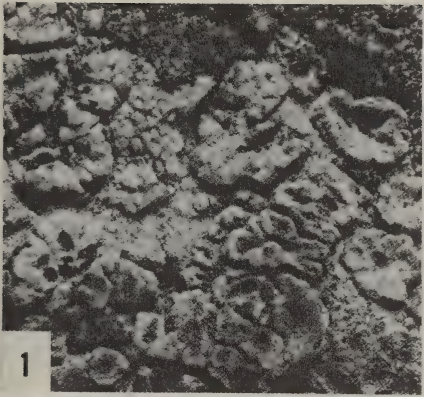
HUILIA FLAVOCAERULESCENS (Hornem.) Hertel (Syn. Lecidea f. Hornem.) - S.W. Greenland: Sdr. Isortoq, Pingo, 65°36'N 51°50'W, 75 m, on gneissic rock; one specimen, leg. V. Alstrup. - W. Greenland: Diskofjord, Nipisat, 69°26'N 54° 09'W, on basaltic rock; one specimen, leg. P. Gelting. - Diskofjord, Eqalunguit, 69°33'N 53°36'W, on basaltic stone; one specimen, leg. P. Gelting. - W. Disko, N. Laksebugt, 69°38'N 54°49'W, on basaltic stone; one specimen, leg. P. Gelting. - S.E. Greenland: Angmagssalik, 65°36'N 37°38'W, on norite; one specimen, leg. E. Steen Hansen.

The species has previously been reported from three localities in W. Greenland, viz. Godthåb, Sinigfik and Malingiaq (Lynge 1937). It is new to E. Greenland. H. flavocaerulescens probably belongs to the element of circumpolar, arctic-alpine lichens (Thomson 1979).

LECANORA CENISIA Ach. (Syn. L. atrynea (Ach.) Nyl.) - S.W. Greenland: Godthåbsfjord, Ilulialik (west of Igassup qâqa), 64°51'N 50°38'W, 50 m, on siliceous rock; one specimen, leg. V. Alstrup. - Kangerdluarssuk, Qivage, 65°29'N 52°31'W, 100 m, on gneissic rock; one specimen, leg. V. Alstrup. - Sdr. Isortoq, south of river Isuitsup kûa, 65°34'N 51°42'W, 100 m, on weathered gneiss, one specimen, leg. V. Alstrup. - Sdr. Isortoq, Pingo, 65°36'N 51°50'W, 100 m, on gneissic rock; one specimen, leg. V. Alstrup. - C.W. Greenland: Arfersiorfik Fjord, Kuánit, 68°05'N 52°12'W, 10 m, on vertical face of gneissic rock; one specimen, leg. P. Gelting. - Arfersiorfik Fjord, Tarajornitsoq, 68°08'N 52°10'W, 6 m, on moist gneissic rock; one specimen, leg. P. Gelting. - Arfersiorfik Fjord, Serfartôq Isl., 68°13'N 52°41'W, on gneissic rock; one specimen, leg. P. Gelting. - Tupilak Isl., 68°42'N 52°53'W, 10 m, on vertical face of gneissic rock; one specimen, leg. P. Gelting. - Igdluko, 68°49'N 51°11'W, 20 m, on rock; one specimen, leg. P. Gelting. - S. Disko, Godhavn, 69°15'N 53°33'W, several sites, e.g., overhanging gneissic rocks, but L. cenisia also occurs on basaltic rocks around Godhavn; 15 specimens, leg. P. Gelting. - S. Disko, Fortunebay, 69°16'N 53°44'W, 4 m, on W.-exposed, vertical, gneissic rock; one specimen, leg. P. Gelting. - Fortunebay, Igdluruneq, 69°16'N 53°49'W, 10 m, on gneissic rock; one specimen, leg. P. Gelting. - S. Disko, Blåfjeld, Nuk kitleq, 69°22'N 54°15'W, 20 m, on W.-exposed basalt-wall influenced by guano; two specimens, leg. P. Gelting. - S. Disko, Skanseklippen, 69°25'N 52°30'W, 15 m, on basaltic boulder; one specimen, leg. P. Gelting. - Diskofjord, Kangikitleq, 69°27'N 53°30'W, 6 m, on basaltic rock; one specimen, leg. P. Gelting. - Diskofjord, Qivitut, 69°27'N 53°40'W, 6-10 m, on E.-exposed, vertical, gneissic rocks; two specimens, leg. P. Gelting. - Diskofjord, Storø (Qegertaq), 69°31'N 54°06'W, 10 m, on manured basaltic rock; one specimen, leg. P. Gelting. - Diskofjord, Kuánit, 69°34'N 54°18'W, on basaltic rock; one specimen, leg. P. Gelting. - W. Disko, Tuno, c. 69°30'N 53°00'W, 12 m, on basaltic stone in brook; one specimen, leg P. Gelting. - W. Disko, N. Laksebugt, 69°38'N 54°49'W, 6 m, on basaltic boulder; one specimen, leg. P. Gelting. - E. Disko, Mudderbugten, Alákariaq, 69°44'N 51°57'W, 30 m, on rock; one specimen, leg. V. Alstrup. - Mudderbugten, Kvandalen, 69°44'N 52°13'W, on basaltic rocks; two specimens, leg. V. Alstrup. - W. Disko, Mellemfjord, Sarqardlit silardlít, 69°47'N 54°44'W, 6 m, on basaltic boulder; one specimen, leg. P. Gelting. - Mellemfjord, Enoks Havn, 69°47'N 54°55'W, 10 m, on basaltic rock; one specimen, leg. P. Gelting. - Nûgssuaq Peninsula, Atanikerdluk, 70°04'N 52°23'W, 10-15 m, on siliceous rock; two specimens, leg. P. Gelting. - E. Disko, Qutdligssat, 70°05'N 53°01'W, 20 m, on basaltic boulder; one specimen, leg. P. Gelting. - S.E. Greenland: Angmagssalik, 65°36'N 37°38'W, on mainly vertical to overhanging faces of rocks composed of norite; four specimens, leg. E. Steen Hansen.

Poelt & Vězda (1981) consider L. cenisia to be an extremely variable and plastic species. These authors include L. atrynea in this species, while others, e.g., Ozenda & Clauzade (1970) keep them as two separate species. Wirth (1980) states that "var. atrynea" primarily occurs in open situations, whereas L. cenisia grows on more or less shady, vertical and overhanging faces of rocks. The Greenland populations of L. cenisia are also characterized by a great morphological variation that, however, not is distinctly correlated with the type of habitat. Further

Fig. 1: Acarospora schleicheri (Ach.) Massal. Fertile thallus growing on Diploschistes and loess on slope near the airport of Søndre Strømfjord. Coll.no. 85532 (x 6). 2: Acarospora sinopica (Wahlenb.) Körb. Areoles with apothecia occurring on norite rich in iron minerals at Angmagssalik. Coll. no. 85277 (x 11). 3: Aspicilia caesiocinerea (Nyl. ex Mallbr.) Arn. Fertile thallus growing on a basaltic birdrock on Blåfjeld. Coll. no. 14424 (x 12). 4: Aspicilia sanguinea Krempelh. Central part of thallus with numerous apothecia from a basaltic boulder on Storø. Coll. no. 13878a (x 12). 5: Cetraria andrejevii Oxner. Wrinkled thallus-lobes from specimen collected at Mesters Vig (left) and canaliculate thallus-lobes without wrinkles from specimen collected at Narssaq (right)(x 1.3).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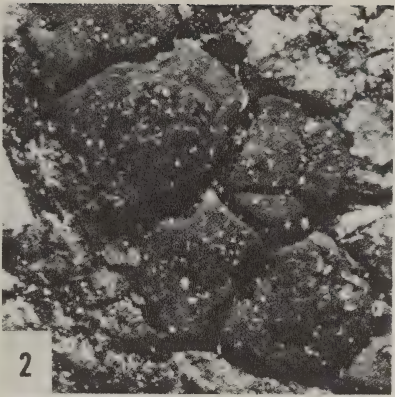
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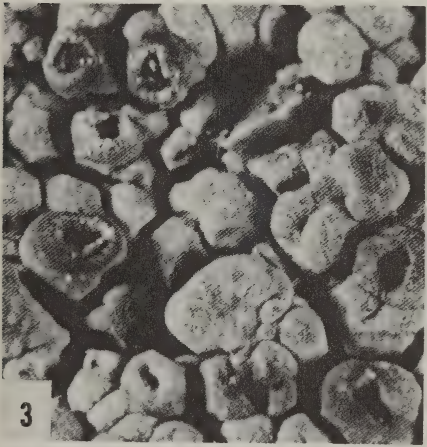
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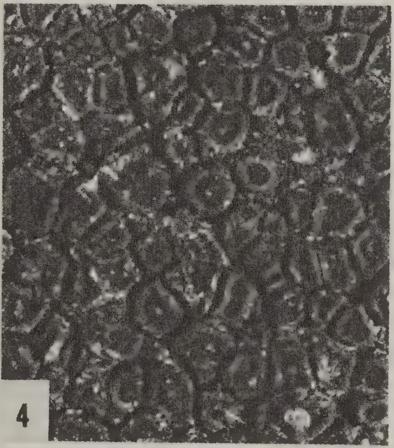
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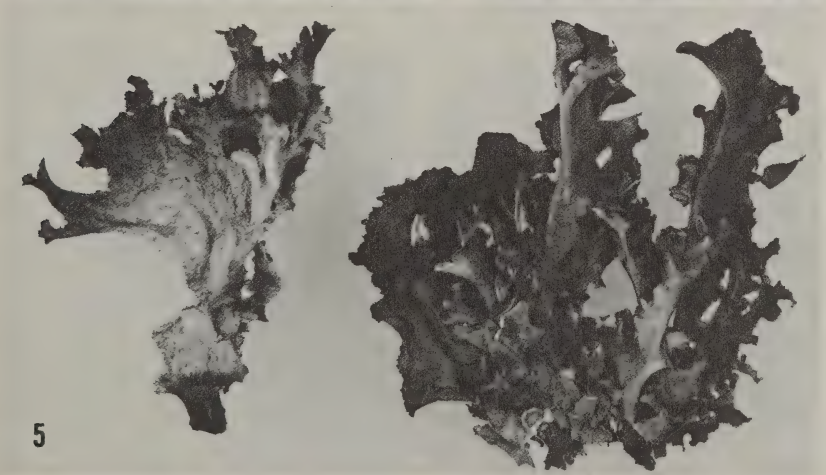
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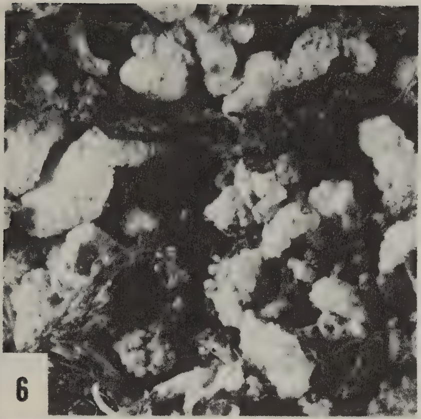
collecting activity and taxonomical work is needed, before this problem can be solved.

Two old collections of "L. cenisea" from E. Greenland appear to be wrongly identified. These plants were found growing on bones. Thus the four new specimens of L. cenisia from Angmagssalik are the first from E. Greenland. However, most of the previous reports of L. cenisia from W. Greenland appear to be correct (Branth & Grønlund 1888), but the newer specimens show that the species is much more common in C.W. Greenland than previously supposed. A great part of the W. Greenland collections of L. cenisia were revised by I. Brodo.

The species is widely distributed in alpine and northern areas on the northern hemisphere.

LECIDEA ATROFULVA Sommerf. - S.W. Greenland: Iglutalik, 60°53'N 46°06'W, 140 m, on rock; one specimen, leg. V. Alstrup. - Godthåbsfjord, Kanasut, 64°20'N 51°43'W, 100 m, on rock; one specimen, leg. V. Alstrup. - Nordlandet, Kanásut narssartarssuat, 64°21'N 51°43'W, 40 m, on siliceous rock; one specimen, leg. V. Alstrup. - Nordlandet, Sârdlup qáqâ, 64°23'N 51°42'W, 140 m, on gneissic rock; one specimen, leg. V. Alstrup. - Nordlandet, Kuánit nuat, 64°24'N 51°37'W, on basaltic rock; one specimen, leg. V. Alstrup. - Godthåbsfjord, Sagdlerssuaq, 64°50'N 50°30'W, 120 m, on siliceous rock at river together with *Tremolecia atrata* and *Hymenelia lacustris*; one specimen, leg. V. Alstrup. - Kangerdluarssuk, bay east of settlement, 65°25'N 52°30'W, 50 m, on siliceous rock; one specimen, leg. V. Alstrup. - Kangerdluarssuk, east of fjord, 65°28'N 52°27'W, 100 m, on siliceous rock rich in Fe together with *Huilia melinodes*; one specimen, leg. V. Alstrup. - Sdr. Isortoq, Nûk, 65°30'N 52°09'W, on siliceous rocks; two specimens, leg. V. Alstrup. - Sdr. Isortoq, Idglut kangigdlit, 65°31'N 52°01'W, on gneissic rock; two specimens, leg. V. Alstrup.

Fig. 6: Cladonia luteoalba A. Wils & Wheld. Primary squamules growing on soil rich in humus in snowbed at Angmagssalik. Coll. no. 85258 (x 6). 7: Huilia flavocaerulescens (Hornem.) Hertel. Fertile thallus growing on norite at Angmagssalik. Coll. no. 8539 (x 6). 8: Lecanora cenisia Ach. Richly fertile thallus growing on norite at Angmagssalik. Coll. no. 85178 (x 6). 9: Lecidea atrofulva Sommerf. Sterile areoles on a black hypothallus from norite rich in iron at Angmagssalik. Coll. no. 8515 (x 30). 10: Rinodina mucronatula H. Magn. Thallus with numerous apothecia (upper) growing on a twig of Salix at Godhavn. Coll. no. 16462a (x 20). Lower right: apothecia belonging to Rinodina archaea (Ach.) Vain. 11: Rinodina soredicola Degel. Apothecia and thallus (middle) growing parasitically on soralia of Lobaria from Agpaqarfik. Coll. no. 16282a (x 10).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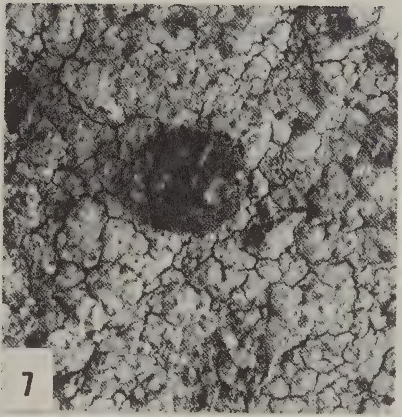
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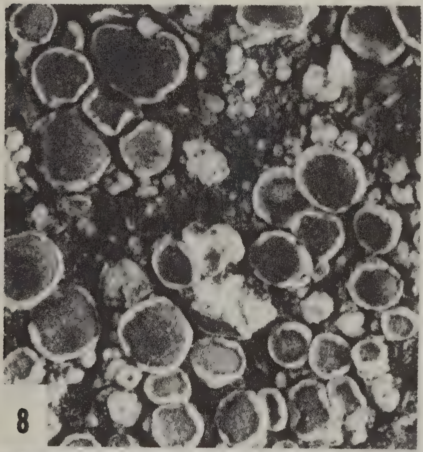
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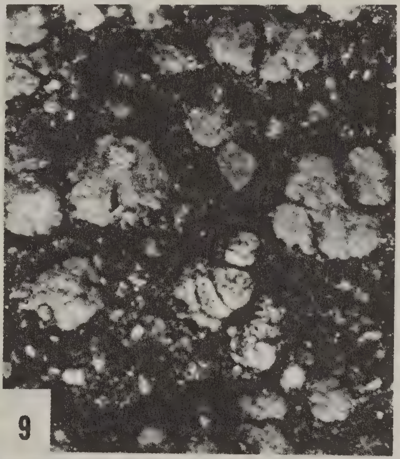
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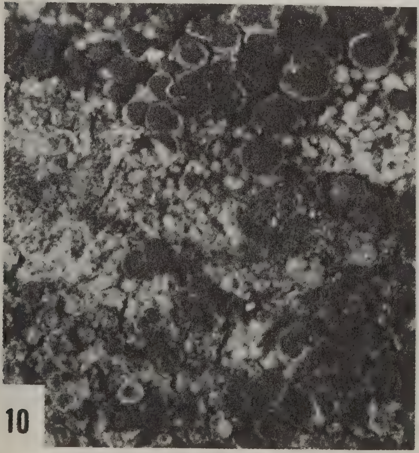
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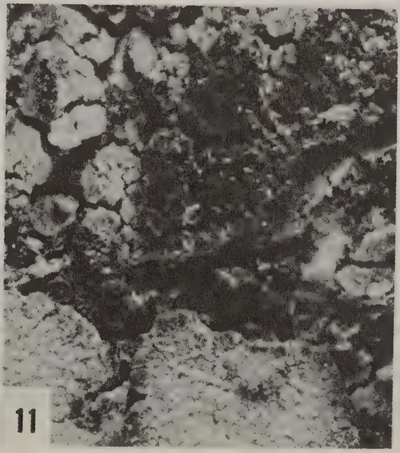
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- S.E. Greenland: Angmagssalik, 65°36'N 37°38'W, on norite rich in Fe together with *Tremolecia atrata*, *Huilia melinodes* and *Umbilicaria torrefacta*; four specimens, leg. E. Steen Hansen.

The above list shows that in Greenland L. atrofulva usually occurs on different types of siliceous rocks inclusive of rocks with some contents of Ca (Angmagssalik). The species was found growing on a basaltic rock at one locality, only. No collections of it are available from the basaltic areas on Disko and other northern areas in Greenland. Presumably L. atrofulva has not been overlooked here, as it is a rather conspicuous species with its rust red areoles that occur either scattered on a distinct black hypothallus or form a more continuous areolate crust on the rock surface. The Greenland specimens of L. atrofulva are sterile, but the characteristic grey, convex to more or less swollen soralia are always present.

According to Wirth (1980) L. atrofulva is distributed in arctic-temperate and alpine areas. It is new to Greenland.

LECIDEA INSULARIS Nyl. (Syn. L. intumescens (Flk. ex Flot.) Nyl. - C.W. Greenland: Ikamiut, 68°38'N 51°50'W, 25 m, growing parasitically on *Lecanora rupicola* on NW.-exposed gneissic rock; one specimen, leg. P. Gelting. - S.Disko, Blåfjeld, Oqaitsunguit, 69°19'N 54°03'W, 6-8 m, on *Lecanora rupicola* on the top of basaltic boulder influenced by guano; one specimen, leg. P. Gelting. - Diskofjord, Kuânit, 69°34'N 54°18'W, 15 m, on basaltic boulder in heath dominated by *Vaccinium uliginosum*; three specimens, leg. P. Gelting.

The specimens, all of them richly fertile, agree well with the description given by Hertel (1970). They are of great interest, as they represent a considerable northward extension of L. insularis into the arctic area (from 63° N to 68-69°N).

The species is an addition to the known lichen flora of Greenland. Its distribution in Europe has been mapped by Hertel (1970).

LECIDEA SILACEA (Ach.) Ach. - S.E. Greenland: Angmagssalik, 65°36'N 37°38'W, on norite (a basic rock with high contents of Al, Fe, Mg and Ca) especially rich in iron minerals together with *Acarospora sinopica*, *Tremolecia atrata* and *Lecanora polytropa* (the colour of the thallus of the last species varies from vaxy yellow to almost rust red. Evidently *Lecanora polytropa* accumulates iron from the norite. Previous investigations have shown that this species is able to accumulate copper on a gneissic rock rich in this element at Godhavn in W. Greenland (Alstrup & E.S. Hansen 1977)).

OCHROLECHIA GRIMMIAE Lynge - S.E. Greenland: Angmagssalik, 65°36'N 37°38'W, on Racomitrium lanuginosum; seven specimens, leg. E. Steen Hansen.

This species was considered very rare in E. Greenland being known previously from one locality, only (E.S. Hansen 1984). However, in the summer of 1985 O. grimmiae was found in several sites around Angmagssalik and accordingly its occurrence can be described as common-occasional at least in this area.

PHYLLISCUM DEMANGEONII (Moug. & Mont. in Mont.) Nyl. - S.E. Greenland: Angmagssalik, 65°36'N 37°38'W, on norite together with Umbilicaria torrefacta, Lecidea atrobrunnea and Pannaria hookeri; three specimens, leg. E. Steen Hansen.

The species is new to the lichen flora of E. Greenland. It has previously been reported from W. Greenland by Dahl (1950) and the present author (E.S. Hansen 1984).

POLYBLASTIA SENDTNERI Krempelh. - C.W. Greenland: S. Disko, Godhavn, Elvebakken, 69°16'N 53°32'W, 9 m, over mosses on boggy ground together with Tofieldia pusilla; one specimen, leg. P. Gelting. - Diskofjord, Eqalunguit, 69°33'N 53°36'W, over mosses and soil on slope along watercourse; one specimen, leg. P. Gelting, det. T.D.V. Swinscow. - C.E. Greenland: Scoresby Sund, Røde Ø, 70°28'N 28°05'W, on soil; one specimen, leg. N. Hartz.

Thallus of the present specimens are moderately thick and greyish white to white. Perithecia occur abundantly. In late stages of development they are somewhat projecting from the thallus with flattened top and distinct ostioles (Ozenda & Clauzade 1970: Fig. 114). The hymenial gelatine is I+ red. The spores are hyaline, ± ellipsoid and muriform. The spore measurements agree well with those mentioned by Poelt (1969).

In his paper on lichens from W. Greenland collected mainly by Th. M. Fries Lynge (1937) discusses some differences between P. sendtneri and P. bryophila Lönnr., and he concludes that none of the specimens of Fries could be referred to P. sendtneri. A revision of the plants from Nordfjord (c. 69°50'N 54°20'W) confirms this statement. A specimen identified as "P. sendtneri" by Lynge in fact belongs to P. bryophila. The perithecia are hemispherical and slightly umbilicate, and the spores are larger than 30 µm. The number of septa is also greater than that of the spores of P. sendtneri.

P. sendtneri has previously been reported from three localities in C.E. Greenland, viz. Danmarks Ø, Cap Stewart and Røde Ø (Branth 1894). I have checked the determinations and find that only the specimen collected by Hartz on Røde Ø belongs to P. sendtneri.

The species is widely distributed in arctic and alpine areas (Poelt 1969; Thomson 1979). It is an addition to the known lichen flora of W. Greenland.

RINODINA MUCRONATULA H. Magn. - C.W. Greenland: S. Disko, Godhavn, 69°15'N 53°32'W, 10 m, on twig of Salix; one specimen, leg. P. Gelting. Prof. John Sheard, Saskatoon, has kindly revised the Greenland collections of this and the following species (R. soredicola).

Thallus of the present specimen is thin and greyish. The apothecia are densely crowded with flat to somewhat convex, black discs surrounded by a distinct, greyish margin. Apically the spores have broadly rounded, hyaline extensions.

The species has previously been reported from Sibiria and Austria (Poelt 1969). There are no previous records of R. mucronatula from Greenland.

RINODINA SOREDICOLA Degel. - C.W. Greenland: Arfersiorfik Fjord, Agpaqarfik, 68°11'N 51°46'W, 30 m, on *Lobaria scrobiculata*; one specimen, leg. P. Gelting.

The brown, granulose thallus of R. soredicola grows parasitically on the soralia of Lobaria (and other lichens with blue-green phycobionts as well). The abundant apothecia are small; the disc to 0.3 mm broad, dark brown to black and rather flat; the margin is somewhat paler. The apical walls of the spores are strongly thickened (Poelt 1969).

R. soredicola is previously known from Fennoscandia and the Alps, but it also ranges into the Arctic. The species is new to the lichen flora of Greenland.

VERRUCARIA DEGELII R. Sant. - C.W. Greenland: Arfersiorfik Fjord, Itivdliarssuk, 67°55'N 50°40'W, on gneissic rocks, c. 30 cm above the *Fucus*-belt together with, e.g., *Verrucaria maura* and *V. erichsenii*; six specimens, leg. P. Gelting. - Arfersiorfik Fjord, Eqaluarssuit, 68°05'N 51° 00' W, on gneissic rocks 0-30 cm above the *Fucus*-zone together with, e.g., *Verrucaria erichsenii*; four specimens, leg. P. Gelting. - Arfersiorfik Fjord, Serfartôq Island, 68°13'N 52°41'W, on gneissic rocks, 1.3 m above the *Fucus*-Balanus-zone; four specimens, leg. P. Gelting. - Arfersiorfik Fjord, Oqaitsut, 68°15'N 53°10'W, 0.3 m, on gneissic rock; two specimens, leg. P. Gelting. - Christianshåb, Sarpiussât, 68°34'N 51°33'W, on gneissic rock 40 cm above the *Fucus*-belt; two specimens, leg. P. Gelting. - Egedesminde: Kangârssutsiaq, 68°34'N 53°08'W, on gneissic rocks, upper part of the *Fucus*-belt; eight specimens, leg. P. Gelting. - Christianshåb, Akugdlît, 68°39'N 51°15'W, on gneissic rock; one specimen, leg. P. Gelting. - Kronprinsens Ejland, Imerigsoq, 69°01'N 53°20'W, on gneissic rocks; three specimens, leg. P. Gelting.

Part of the above specimens have previously been determined by R. Santesson. The thallus is thin to moderately thick, distinctly cracked to areolate, minutely dotted and light grey to greyish brown. Perithecia occur abundantly. The spores measure 10-12(-14) x 6.5-7(-8) µm.

The distribution of V. degelii in Scandinavia (Norway) has been mapped by Santesson (1939). It is an addition to the lichen flora of Greenland.

VERRUCARIA PRAETERMISSA (Trevis.) Anzi (Syn. V. laevata sensu Körb.) - C.W. Greenland: Diskofjord, Kuãnerssuit, Store Kvanli, 69°35'N 53°23'W, 10 m, on basaltic boulder in brook derived from thermal springs; one specimen, leg. P. Gelting.

The species is very variable in colour of the thallus ranging from greyish white to beige and rose-brownish (Wirth 1980). The colour of the thallus of the present specimen can best be described as pale brown with a rose-pink tinge. It is thin and intersected by minute cracks. Perithecia in different stages of development occur numerously. The youngest are entirely imbedded in thallus, while the older perithecia expose their black tops. Many of them are infested with a parasite, and this makes the determination somewhat difficult.

V. praetermissa is mainly distributed in alpine areas, but is also ranging into the arctic regions (Wirth 1980). It is new to the lichen flora of Greenland.

ACKNOWLEDGEMENTS

I wish to thank R.W.M. Corner (Penrith) for providing me with his large collections from E. Greenland. I also wish to thank the Danish Natural Science Research Council for supporting my investigations of mainly epilithic lichens in Greenland. The above-mentioned lichens from Angmagssalik were collected during this study. Ingvar Kärnefelt (Lund) read the manuscript.

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MYCOTAXON

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REDISPOSALS AND REDESCRIPTIONS IN THE **MONOCHAETIA-SEIRIDIUM, PESTALOTIA-PESTALOTIOPSIS** COMPLEXES. V. MONOCHAETIA ALNEA AND M. BERBERIDICOLA

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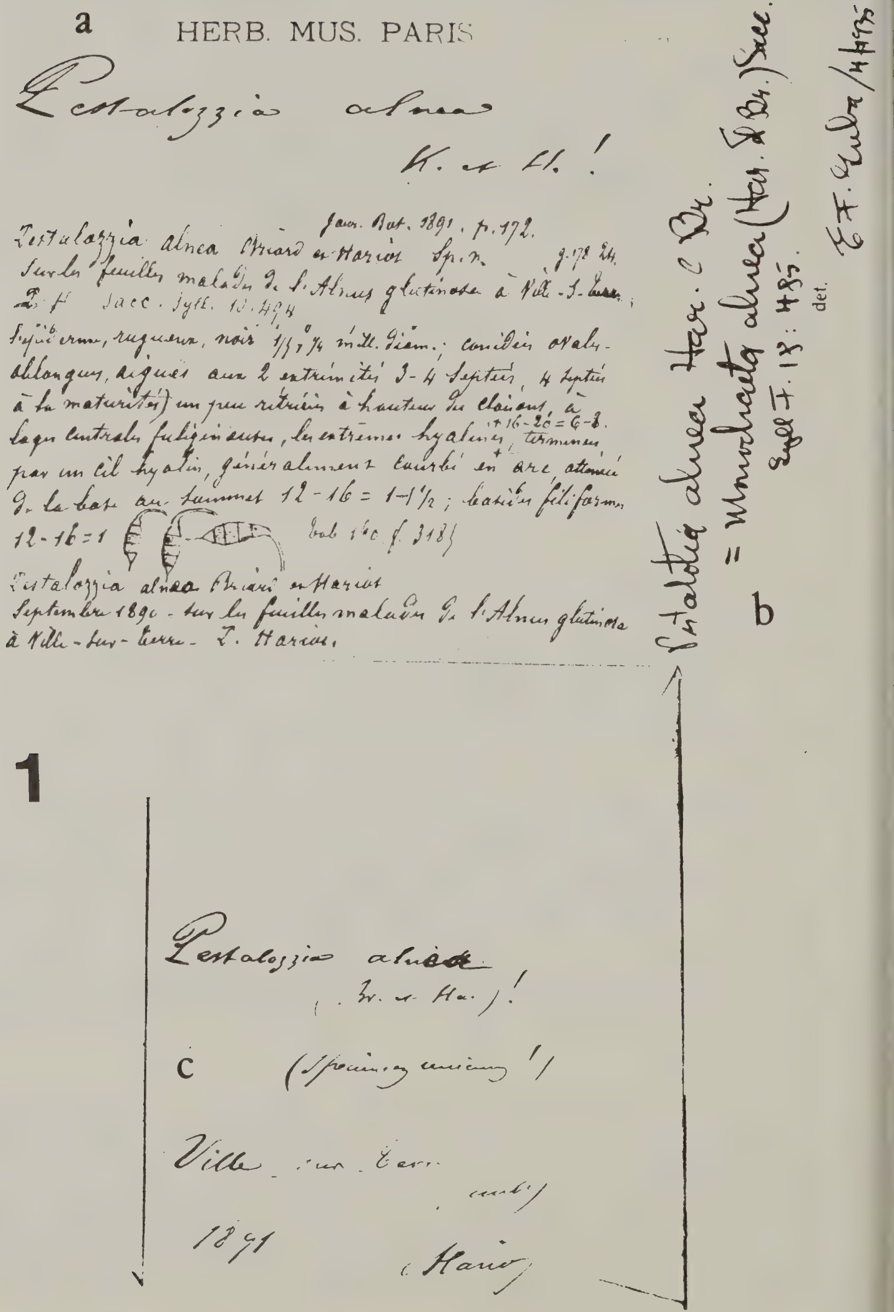
Monochaetia alnea is regarded as a nomen dubium. **Seimatosporium alneum sp. nov.** and **Seimatosporium berberidicolum comb. nov.** are described and illustrated.

5. Monochaetia alnea (Hariot & Briard) Allesch., Rabenh. Krypt. Flora 7: 666, 1902.
= Pestalotia alnea Hariot & Briard, Jour. Bot. Fr. 5: 172, 1891.

On diseased leaves of Alnus glutinosa, Ville-sur-Terre, France, IX.1890, P.Hariot (Type in PC).

Saccardo's (1892) description of Pestalotia alnea Hariot & Briard appears to have been reproduced verbatim by Guba (1961). The original description stressed the following features of the fungus: 'epiphyllous, punctiform, subepidermal, erumpent, globose, pustules 200-250 µm in diam;



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HERB. MUS. PARIS

Pestalozzia alnea
Br. et H.!

Journ. Bot. 1891. p. 172.
Pestalozzia alnea Briard et Hariot Sp. n. g. 78 24.
Sur les feuilles malades de l'Alnus glutinosa à Ville-s-Terre;
D. f. Sacc. Syll. 10. 494
Périthèces érumpents, rugueux, noirs 1/5 à 1/4 mill. diam.; conidies ovales-allongées, aiguës aux 2 extrémités 3-4 septées, 4 septées à la maturité) un peu rétrécies à hauteur des cloisons, à loges centrales fuligineuses, les extrêmes hyalines, +16-20 = 6-8. terminées par un cil hyalin, généralement courbé en arc atténué de la base au sommet 12-16 = 1-1½; basides filiformes 12-16 = 1 (tab. 140 f. 318)

Pestalozzia alnea Briard et Hariot
Septembre 1890 - sur les feuilles malades de l'Alnus glutinosa à Ville-sur-Terre - P. Hariot.

Pestalotia alnea Har. & Br.
= Monochaetia alnea (Har. & Br.) Sacc.
Syll. F. 18: 485.
det. E. F. Guba / 4 1935

Pestalozzia alnea
(Br. et Har.)!
(Specimen unicum!)
Ville-sur-Terre
(Aube)
1891 (Hariot)

Figure 1. Monochaetia alnea. Copy of label on herbarium packet showing notes and pencil sketches (a,c) by original authors and Guba's annotation concerning the fungus (b).

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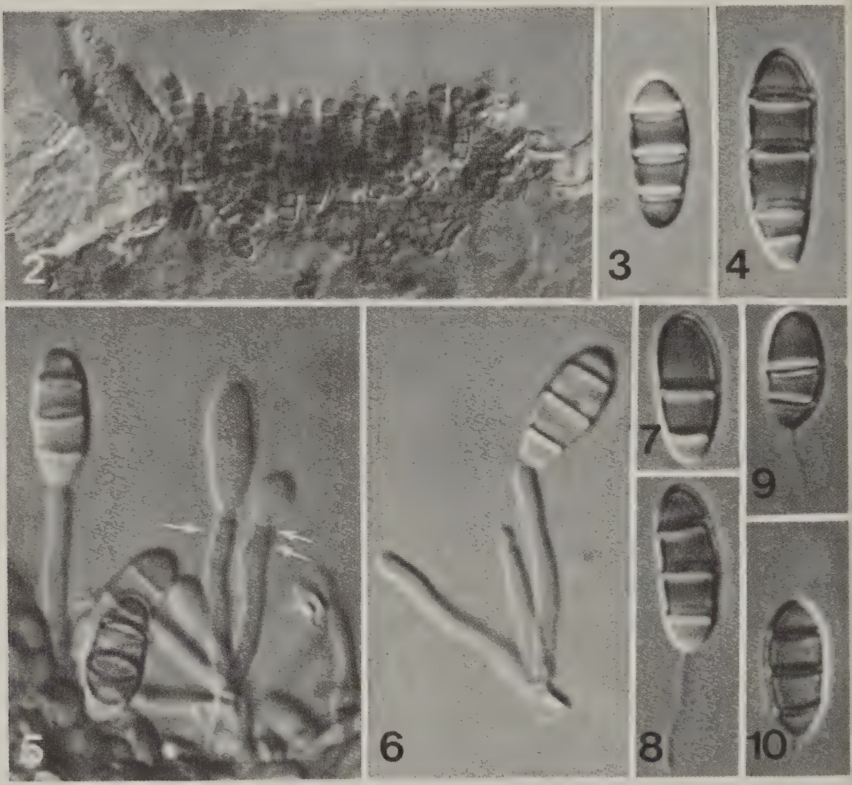
ovate-elongate conidia with pointed ends and 3-4 septa, 16-20 x 6-8 µm, brown median cells, hyaline exterior cells, apical cell with a hyaline, often curved setula, 12-16 µm long; filiform, pedicels 12-16 µm long.'

Through the courtesy of Dr. Jean Mouchacca, I have been able to examine the original specimen housed in PC. According to the notes on the packet (Fig. 1a), Hariot appears to have collected the fungus from the type locality in 1890 and again in 1891. The 1890 specimen is the type, and as indicated by the annotation (Fig. 1b) Guba examined it in 1955 and accepted it as a Monochaetia. The 1891 specimen appears to be missing (Fig 1c). Hariot's annotation and pencilled sketches clearly depict a fungus that may belong in Monochaetia. Three conidia are shown with 3 fuliginous, median cells and hyaline end cells, a curved apical appendage and a centric, filiform basal appendage. Dimensions reported on the label were: conidia -- 16-20 X 6-8 µm; apical appendage-- 12-16 X 1-1.5 µm; basal appendage-- 12-16 X 1 µm.

A careful scrutiny of the specimen, however, did not reveal any fungus that could be assigned to Monochaetia. The collection did, however, bear a species of Seimatosporium. A detailed study of this fungus indicates that it was not the taxon that Hariot & Briard were dealing with, when they reported Pestalotia alnea from the specimen. The absence of anything recognizable as P. alnea, and the lack of satisfactory illustrations and description, prevent an unequivoval decision concerning P. alnea. Since the prevailing data cannot be satisfactorily incorporated into the modern generic concept of Monochaetia, I consider the binomial P. alnea a



Figures 2-10. **Seimatosporium alneum** ex type of *Monochaetia alnea* in PC (All with Nomarski Interference phase contrast). Fig. 2. Vertical section of a conidioma. X 480. Figs. 5, 6. Conidiophores and conidiogenous cells. Arrows mark annellations. X 2000. Figs. 3,5,7-10. Mature conidia with 2-4 septa and with or without basal appendages. X 2000.

nomen dubium.

The species of *Seimatosporium* encountered on the specimen appears to be quite distinct from any of the species accepted by Sutton (1980). It is interesting to note that Sutton (1975) considered that *Coryneum confluens* T.F.L. Nees von Esenbeck, originally reported from *Alnus*, possibly belonged in *Seimatosporium*. The herbarium of T. Nees was destroyed during the second world war. Except for the original description and the subsequent brief descriptions published by Saccardo (1884), Allescher (1903) and Diedicke (1915), no reliable account or illustration of the fungus has ever been published. According to the original description, the conidia are consistently 3-septate. The epithet 'confluens' could have been considered for the taxon described below, but the application of this name is in doubt due to lack of reference material.

I consider the Seimatosporium species on Alnus sp. in Hariot's collection distinct and describe it as follows:

Seimatosporium alneum sp. nov. Figs. 2-11

Foliicola. Conidiomata stromatica, acervularia, epiphylla, raro hypophylla, dissita ad gregaria, originem subcuticularia, erumpentia, ambitu ovali ad orbiculari vel irregulari, 90-150 X 40-50 µm, glabra, nigra; rima in cuticula hospitis dehiscentia; stroma basale usque ad 50 µm cr., e 'textura angularis' ex cellulis moderatim crasse tunicatis, hyalinis, laevis composita. Conidiophora ex cellulis strato superno stromate basali exorientia, septata et tantum basim ramosa, hyalina, laevia, 50-60 µm longa, in muco involuta. Cellulae conidiogenae annellidicae, lageniformes vel teretes, hyalinae, laeviae, tenuitunicatis, laeviae, 10.5-18 X 2-2.5 ($\bar{x}$ = 13.5 X 2.2) µm, usque ad ter percurrenter prolificantes. Conidia blastico-annellidica, ellipsoidea, vulgo 3-septata, interdum 2-septata vel 4-septata, pariete laevi et septiis constricto, 11-19 X 5-6 ($\bar{x}$ = 15 X 5.5) µm; cellula basalis obconica, base truncato minute fimbria marginali ferenti, subhyalina, 2.5-4(-4.5) ($\bar{x}$ = 3.2) µm longa; duae cellulae medianae (interdum una cellula centralis) breve cylindraceae vel doliiformes, pallide brunneae, omnino 6-9(-10) ($\bar{x}$ = 7.5) µm (utraque cellula 3-5 µm) longa; cellula apicalis conica, apice rotundata, pallide brunnea (2.5-)3-4 ($\bar{x}$ =

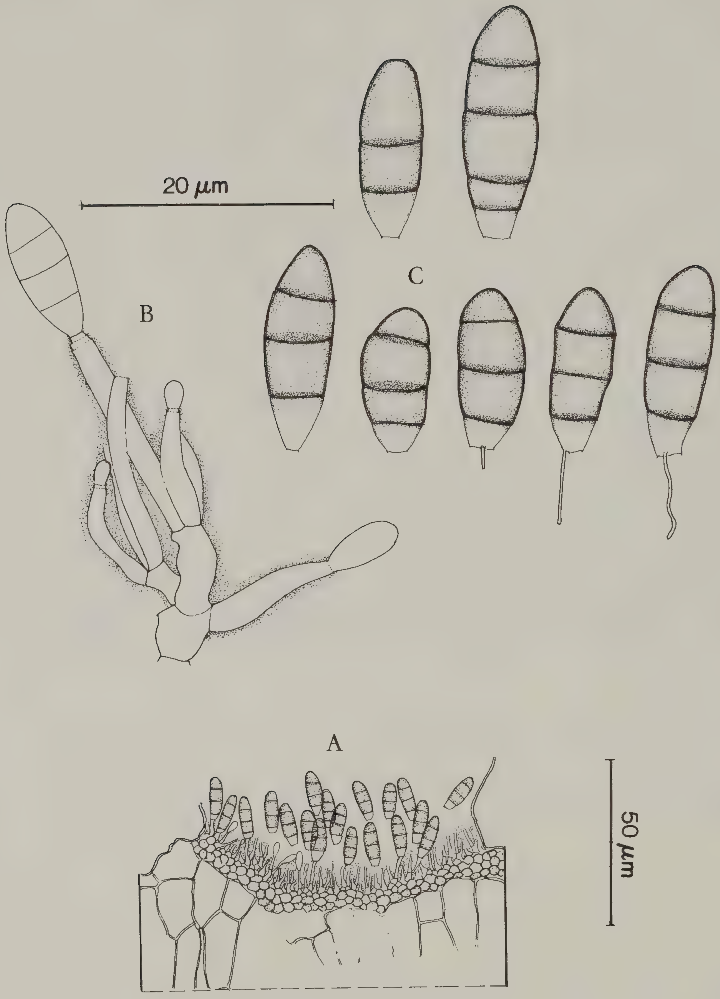


Figure 11. **Seimatosporium alneum** ex type of *Monochaetia alnea* in PC. A. Vertical section of a conidioma. B. Conidiophores. C. Mature conidia.

3.5) µm longa, longiore (usque ad 7 µm) in conidiis 2-septatis; appendix apicalis nulla; appendix basalis saepissime nulla, autem ubi praesens, tubularis, singulis, nonramosis, excentrica, (1.5-)2.5-8 ($\bar{x}$ = 5.3) µm longa; ratione conidii long./lat. = 2.7:1.

Foliicolous. Conidiomata stromatic, acervular, epiphyllous, rarely hypophyllous, scattered to gregarious, subcuticular in origin, erumpent, oval to orbicular or irregular in outline, 90-150 µm wide, 40-50 µm deep, glabrous, black, dehiscing by a break in the overlying host cuticle; basal stroma up to 50 µm thick, of 'textura angularis', cells moderately thick-walled, hyaline, smooth. Conidiophores arising from the upper layer of cells of the basal stroma, septate and branched only at the base, hyaline, smooth, 50-60 µm long, invested in mucus. Conidiogenous cells annellidic, terete to lageniform, hyaline, thin-walled, smooth, 10.5-18 X 2-2.5 ($\bar{x}$ = 13.5 X 2.2) µm, with up to 3 annellations. Conidia blastic-annellidic, ellipsoid, mostly 3-septate, occasionally 2-septate or 4-septate, wall smooth and sometimes constricted at the septa, 11-19 X 5-6 ($\bar{x}$ = 15 X 5.5) µm; basal cell obconic with a truncate base bearing minute marginal frills, subhyaline, 2.5-4(-4.5) ($\bar{x}$ = 3.2) µm long; central cell or the two median cells short cylindric to doliiform, pale brown, together 6-9(-10) ($\bar{x}$ = 7.5) µm (each cell 3-5 um) long; apical cell conic with a rounded apex, pale brown and concolorous with the median cells, (2.5-)3-4 ($\bar{x}$ = 3.5) µm long in 3-septate forms, longer (up to 7 µm) in 2-septate forms; apical appendage absent; basal appendage lacking or, when present, tubular, single, unbranched, excentric, (1.5-)2.5-8 ($\bar{x}$ = 5.3) µm long; mean conidium length/width ratio = 2.7:1.

Habitat: On leaves of Alnus glutinosa.

Specimen examined: PC (Holotype), Ville-sur-Terre, France, IX.1890, P.Hariot.

Known distribution: France.

Teleomorph: Unknown.

The fungus is associated with gray brown, circular leafspots surrounded by brown, indefinite margins, 5-7 mm diam.

6. Monochaetia berberidicola Vassil., Vassil. & Karak., nom. nov., Fungi Imperf., par. 2: 466, 1950.
≡ Monochaetia berberidis Girzitska, Bull. Jard. Bot. Kiev, U.S.S.R. 5-6: 167, 1927; non Monochaetia berberidis Lind in Rostrup, Danish Fungi: 489, 1913.

On branches of Berberis vulgaris, Bot. Gard., Kiev, U.S.S.R, 15.VII.1926, Girzitska (Holotype in LEP).

Girzitska (op. cit.) published the binomial Monochaetia berberidis, unaware that the epithet had been preempted by Lind in 1913. This situation prompted Vassiljevsky et al. (op. cit.) to substitute a new name for the taxon. Guba (1961) published a brief description of the fungus, presumably derived directly from the original. He considered M. berberidicola acceptable in the section 'quadriloculatae' of Monochaetia, although there is no indication that he had based his decision on a first-hand knowledge of the fungus. The description published by Guba (1961) ran as follows: 'Pustules punctiform, sparse, black, innate, 250-350 µm diam. Conidia fusiform, 3-septate, not constricted at the septa, 19-20.6 X 7.6-9 µm; two intermediate cells olivaceous, exterior cells somewhat olivaceous; setulae filiform, hyaline, 3-5 µm long; pedicels hyaline, septate, 30-50 µm long.' This description is ambiguous and does not permit a clear concept of the fungus that Girzitska described as Monochaetia berberidis. As far as I am aware, no satisfactory illustration of the fungus has previously been published.

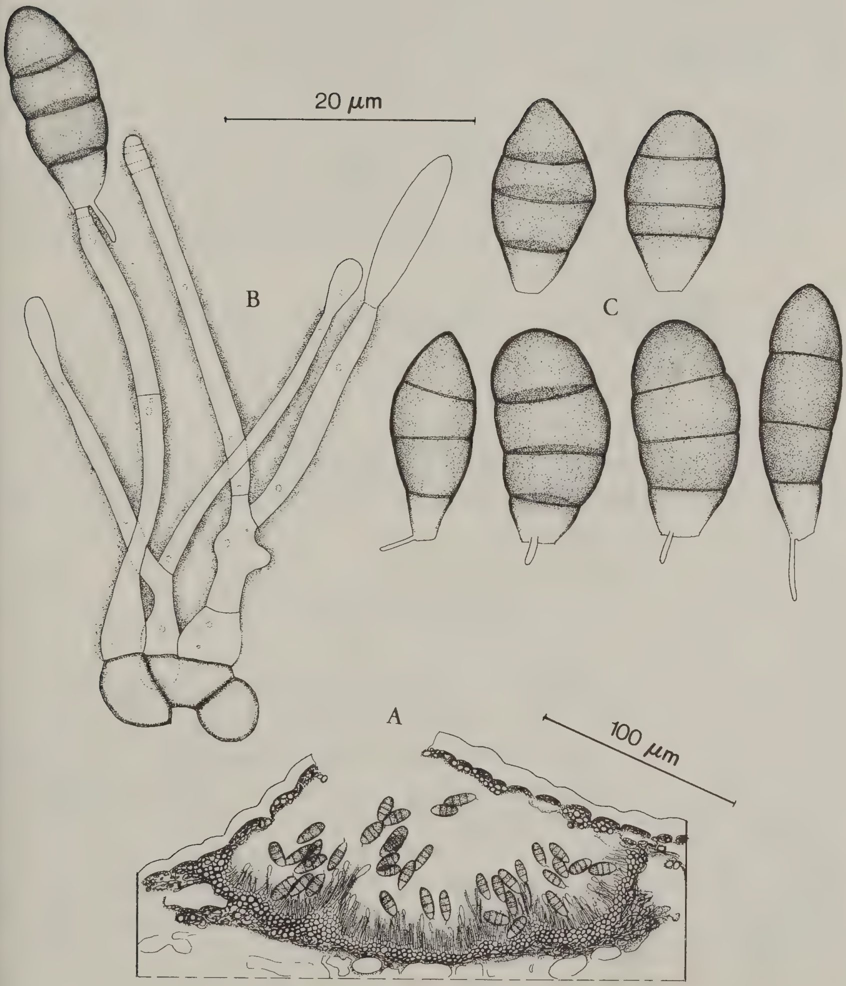


Figure 12. **Seimatosporium berberidicolum** ex type of Monochaetia berberidis in LEP. A. Vertical section of a conidioma. B. Conidiophores and conidiogenous cells. C. Mature conidia.

Through the courtesy of Dr. Mel'nik, I have been able to examine the type specimen of *M. berberidis*. The specimen is in good condition, but does not carry a *Monochaetia*: I found a species of *Seimatosporium*, which is illustrated in Fig. 12 and can be described as follows:

Seimatosporium berberidicola (Vassil., Vassil. & Karak.) **comb. nov.** Fig. 12
≡ *Monochaetia berberidicola* Vassil., Vassil. & Karak., Fungi Imperf., par. 2: 466, 1950.
≡ *Monochaetia berberidis* Girzitska, Bull. Jard. Bot. Kiev, U.S.S.R. 5-6: 167, 1927.

Caulicolous. *Conidiomata* stromatic, acervuloid, scattered to gregarious, occasionally confluent, intraperidermal to subperidermal in origin, suberumpent, oval to ellipsoidal in outline, 190-500 µm wide, 90-150 µm deep, unilocular, occasionally convoluted and divided into two to three incomplete locules, glabrous, black, dehiscing by an irregular split in the overlying host tissue; basal stroma 10-15 µm and 3-4 cells thick, of 'textura angularis', cells thick-walled and brown in the lowermost layers, thin-walled and lighter above. *Conidiophores* arising from the upper cells of the basal stroma, sparsely septate and branched, hyaline, thin-walled, smooth, up to 60 µm long, invested in mucus. *Conidiogenous cells* annellidic, subcylindrical, hyaline, thin-walled, smooth, 15-32 X 1.5-2 ($\bar{x}$ = 22 X 1.7) µm, with up to 4 annellations. *Conidia* blastic-annellidic, clavate to ellipsoidal, straight or bent, predominantly 3-septate, occasionally 4-septate or 6-septate, with the periclinal wall smooth and darker than the septa, 14-21 X 5.5-9.5 ($\bar{x}$ = 17.2 X 7.4) µm; basal cell obconic with a truncate base and minute marginal frills, brown or occasionally light brown, 3.5-6 ($\bar{x}$ = 4.5) µm long; 2 median cells more or less cylindrical, wall slightly constricted at the septa, cells more or less equal in length, together 7-10 ($\bar{x}$ = 8.2) µm long (second cell from base 3.5-4.5 (-5) ($\bar{x}$ = 4) µm long, third cell from base 3.5-5 ($\bar{x}$ = 4.2) µm long); apical cell broadly rounded or occasionally acute at the apex, brown and more or less concolorous with the median cells, 4-6 ($\bar{x}$ = 4.8) µm long; apical appendage absent; basal appendage often lacking, but when present, single, tubular, unbranched, excentric, 2-5 ($\bar{x}$ = 3.5) µm long; mean conidium length/width ratio = 2.3:1.

The salient morphological features of the conidia described above agree with those of M. berberidis, though the latter was described as possessing consistently 3-septate conidia. I consider that M. berberidis belongs in Seimatosporium, though it differs from all appendage-bearing species of Seimatosporium with similar morphology.

Acknowledgments

I thank the curators at LEP and PC for the loan of the specimens examined in this study. I am deeply indebted to Prof. B. Kendrick, Department of Biology, University of Waterloo, and Dr. Amy Rossman, Mycology Laboratory, Beltsville, Md., U.S.A. for critical reviews of this manuscript. The Natural Sciences and Engineering Research Council of Canada provided financial support for this research in the form of an operating grant to Prof. Kendrick.

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REDISPOSALS AND REDESCRIPTIONS IN THE MONOCHAETIA-SEIRIDIUM, PESTALOTIA-PESTALOTIOPSIS COMPLEXES. VI. PESTALOTIA DECOLORATA AND PESTALOTIA HETEROMORPHA

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The generic name Pestalozzina is retained for coelomycetous fungi assignable to Pestalotia decolorata and Pestalotia heteromorpha, which are congeneric with Pestalozzina unicolor. Bartalinia muehlenbeckiae is considered a synonym of P. heteromorpha.

7. Pestalotia decolorata Speg., Anal. Soc. Ci. Argent. 9: 190, 1880; Sacc., Syll. Fung. 3: 784, 1884.

On undetermined member of Myrtaceae, Riachuelo, Buenos Aires, Argentina, 20.II.1880, C.Spegazzini (Holotype in LPS No. 11887).

The type specimen is depauperate; hence the anatomical details of the conidiomata can not be ascertained. The following description and illustration (Fig. 1) are based on an overview of the specimen and squash mounts of a single conidioma.

Foliicolous, associated with circular or oval, discrete, brown to ash-coloured leaf spots with dark margins. Conidiomata stromatic, amphigenous, subepidermal in origin, oval to orbicular in outline, up to 120 µm diam, 50-60 µm deep, unilocular, glabrous, dark brown to black; basal stroma thin, of 'textura angularis', cells moderately thick-walled and pale brown in the lower layers, becoming hyaline above. Conidiophores

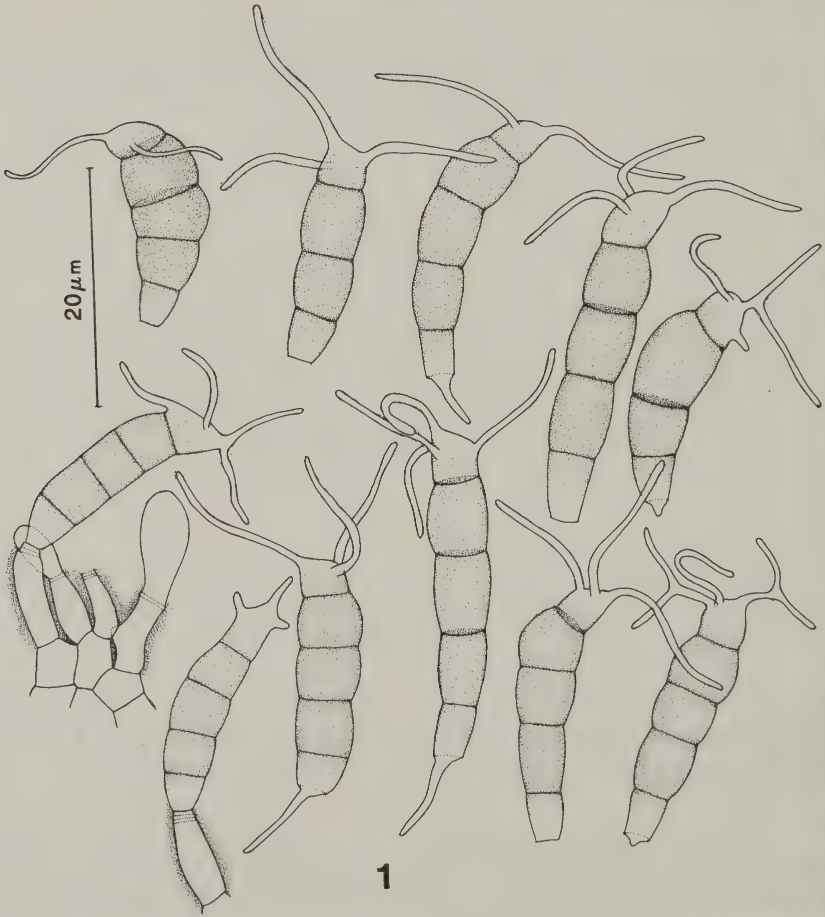

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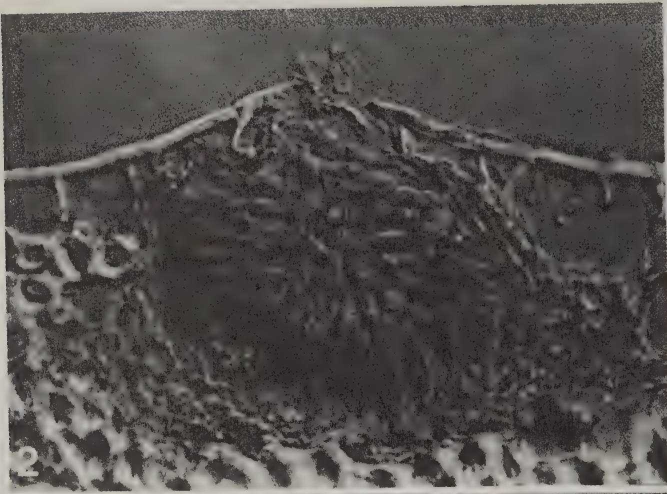
Fig. 1. Pestalozzina unicolor ex type of Pestalotia decolorata in LPS 11887. Conidiogenous cells and conidia.

arising in the concavity of the conidioma, reduced to conidiogenous cells, invested in mucus. *Conidiogenous cells* annellidic, discrete or integrated, lageniform or subcylindrical, hyaline, thin-walled, smooth, 5-11 X 1.5-3 ($\bar{x}$ = 8.3 X 2.3) µm, with up to 3 annellations. *Conidia* blastic-annellidic, fusiform, 3-4-septate, wall smooth and constricted at the septa, 20-30 X 5-6.5 ($\bar{x}$ = 23.2 X 5.6) µm, bearing appendages; basal cell obconic with a truncate base and minute marginal frills, subhyaline in the apical part, 4-5(-6) ($\bar{x}$ = 4.5) µm long; median cells 3 or 2, doliiform, subhyaline, together 11.5-19 ($\bar{x}$ = 15) µm (second cell from base 4-7 ($\bar{x}$ = 5.5) µm long; third cell from base, when present, 4-8 ($\bar{x}$ = 5.5) µm long; fourth cell from base 4-6 ($\bar{x}$ = 5.3) µm long); apical cell short cylindrical with a somewhat rounded apex, subhyaline in the basal part, 2.5-5 ($\bar{x}$ = 4) µm long; appendages arising mostly on the apical and sometimes on the basal cell, tubular, not separated from the conidium body by septa, gradually attenuated, flexuous; appendages on the apical cell axial and abaxial; axial appendage single, mostly unbranched but occasionally forked, 10-15 ($\bar{x}$ = 12.5) µm long; abaxial appendages 1-3, arising at different loci in a submedian position on the convex side, divergent, (2-)8-13 ($\bar{x}$ = 10.2) µm long; basal appendage, when present, single, unbranched, centric, 1-7 ($\bar{x}$ = 4.5) µm long; mean conidium length/width ratio = 4:1.

Guba (1961) considered *P. decolorata* and *P. myrticola* Bubák synonyms of *Pestalozzina unicolor* Berk. & Curt. Although the conidia of *Pestalozzina unicolor* are consistently 4-septate and the total length of the median cells of the conidia is relatively less compared to the conidia of *P. decolorata*, I concur with Guba's redisposition of the fungus. An illustration of *P. unicolor* has been published by Nag Raj (1974).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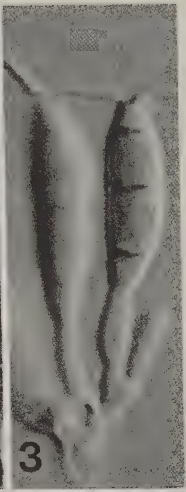
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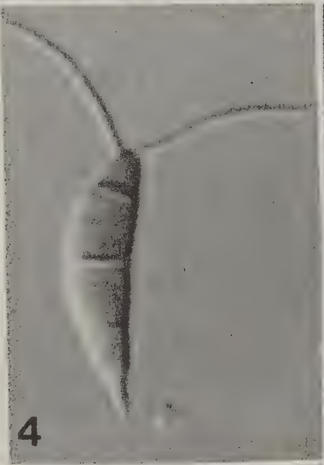
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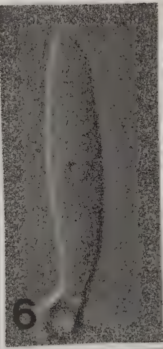
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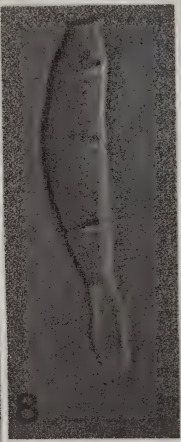
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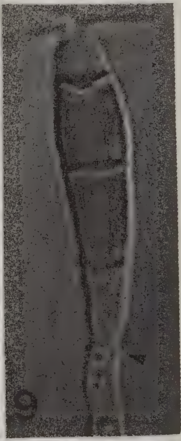
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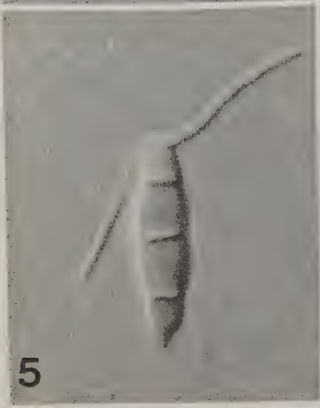
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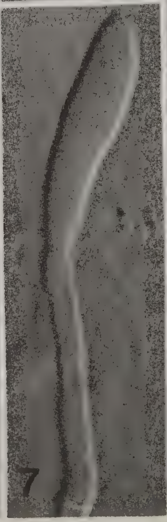
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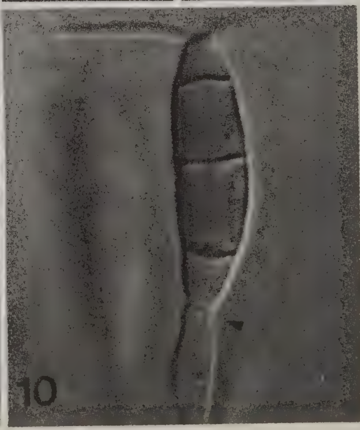
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Figs. 2-10. Pestalozzina heteromorpha ex type in BPI (all under Nomarski interference phase-contrast optics). Fig. 2. v.s. conidioma; Figs. 3, 6-10. Conidiophores, conidiogenous cells and developing conidia. Arrowheads mark annellations; Figs. 4, 5. Mature conidia. Fig. 2 ca X 480; Figs. 3-5 X 1280; Figs. 6-10 X 2000.

Another fungus that has a close affinity with P. unicolor is considered below:

8. Pestalotia heteromorpha Thum., Inst. Rev. Sci. Litt. Coimbra, ser. 3, 28: 575, (1880) 1881; Sacc., Syll. Fung. 3: 794, 1884.

On leaves of *Polygonum platycladum, Bot. Gdn., Univ. Coimbra, Portugal, VIII.1879, A.Möller No. 637.

According to Guba (1961), the original description of the fungus emphasized acervular conidiomata; 3-septate hyaline conidia attenuated at both ends and with constrictions in the wall at the septa, bearing 3 divergent 'setulae' at the apex and short 'pedicels' at the base. An annotation slip accompanying the specimen in BPI indicates that Guba had examined the specimen and considered redisposition of the fungus in Pestalozzina. However, Guba (1961) chose not to publish the appropriate combination, excluded it from Pestalotia, and suggested that it had affinity with Bartalinia.

The following description and illustrations in Figs. 2-11, are based on the study of the type specimen in BPI and a recent collection from Australia.

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*According to Airy Shaw (Flowering Plants and Ferns, Univ. Press, Cambridge, 1973), Polygonum platycladum and Muehlenbeckia platyclados are synonyms of Homalocladium platycladium.

Foliicolous. Conidiomata stromatic, pycnidioid, amphigenous, scattered to gregarious, occasionally confluent, partly erumpent, oval to orbicular in outline, globose to depressed globose in sectional view, 80-140 µm wide, 50-110 µm deep,

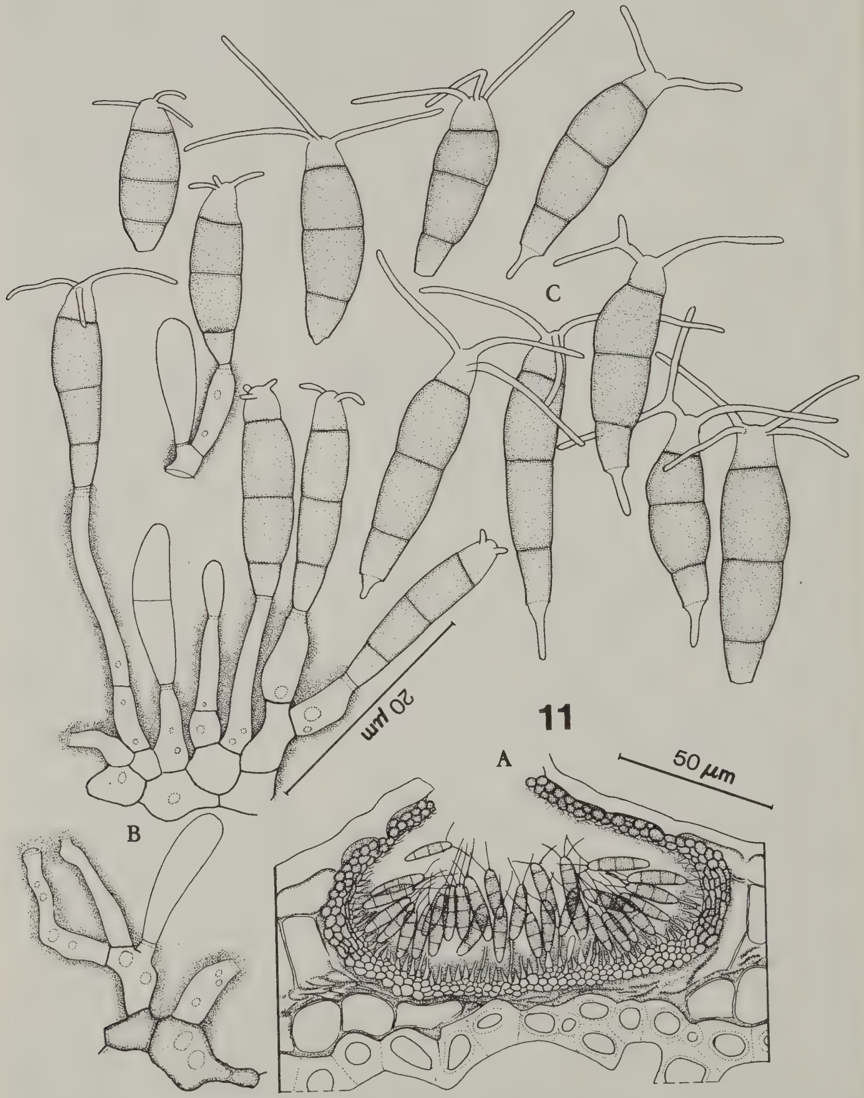

Fig. 11. Pestalozzina heteromorpha ex type in BPI. A. v.s. conidioma. B. Conidiophores and conidiogenous cells with developing conidia. C. Mature conidia.

unilocular, glabrous, pale brown to brown, occasionally black; dehiscence by a break in the overlying tissue; wall thin, of 'textura angularis', cells moderately thick-walled, subhyaline to hyaline. Conidiophores arising from the innermost layer of cells of the wall all around the cavity of the conidioma, sparsely septate and branched, occasionally reduced to conidiogenous cells, hyaline, smooth, up to 20 µm long, invested in mucus. Conidiogenous cells annellidic, cylindrical to subcylindrical or lageniform, hyaline, smooth, guttulate, 6-9(-17) X 1.5-3 ($\bar{x}$ = 7.5 X 2.2) µm with up to 4 annellations. Conidia blastic-annellidic, fusiform, 3-septate, wall smooth and often constricted at the septa, subhyaline to hyaline, guttulate, (12.5-)14.5-26 X 4-6 ($\bar{x}$ = 20 X 5) µm, bearing appendages; basal cell obconic with a narrow truncate base, thin-walled, subhyaline, bearing minute marginal frills, (2-)3-5 ($\bar{x}$ = 4) µm long; 2 median cells subcylindrical, thick-walled, subhyaline, more or less equal, together 7.5-17.5 ($\bar{x}$ = 12.5) µm long (second cell from base (3.5-)5.5-7.5(-9) ($\bar{x}$ = 6.5) µm; third cell from base 4.5-8.5 ($\bar{x}$ = 6.5) µm long; apical cell broadly conical with a somewhat rounded or obtuse apex, subhyaline to hyaline, (2-)3-4 ($\bar{x}$ = 3.5) µm long; appendages arising mostly on the apical cell, sometimes on the basal cell, tubular, not separated from the conidium body by septa, gradually attenuated, flexuous; appendages on the apical cell axial and abaxial; axial appendage single, occasionally forked, 4-14 ($\bar{x}$ = 9) µm long; abaxial appendages 2-4, arising at different loci close to the apex on the convex side, divergent, one of them occasionally forked, often unequal, as long as the apical appendage; basal appendage, when present, single, unbranched, centric, 1-5.5 ($\bar{x}$ = 3.5) µm long; mean conidium length/width ratio = 4:1.

Habitat: On dead leaves of *Homalocladium

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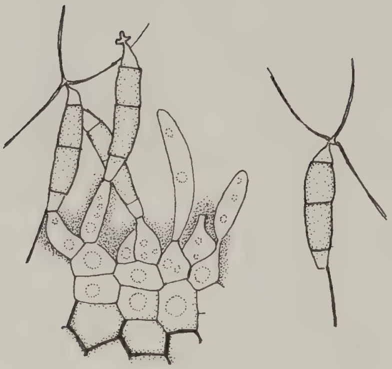
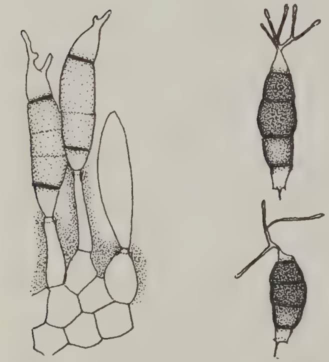
*See foot-note on p. 203.

Features of conidia



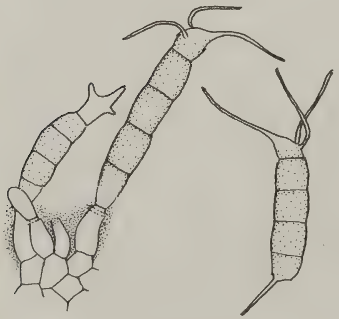
Bartalinia

Ontogeny: blastic-solitary
Septa: 3-4
apical cell: **empty**
apical appendages: single
  branching: 1X, proximal, trifid/ quadrifid
basal appendage: single, **not from basal scar**



Pestalotiopsis

Ontogeny: blastic-phialidic
Septa: 3-4
apical cell: **empty**
apical appendages: 1/many, irregular
branching: 0-1X, distal, bifid/ irregular
basal appendage: single (when present), **from basal scar.**



Pestalozzina

12

Ontogeny: blastic-annellidic
Septa: 3-4
apical cell: with cytoplasm
appendages: axial and abaxial
  axial: single
  abaxial: 1-4
  branching: 0-1X, distal, bifid
basal appendage:single (when present), **from basal scar.**

Fig. 12. Synoptic plate highlighting the diagnostic differences between **Bartalinia**, **Pestalotiopsis** and **Pestalozzina**.

platycladium.

Specimens examined: 1. BPI (Type), Bot. Gdn., Univ. Coimbra, Coimbra, Portugal, VIII.1879, A.Moller No. 575, (ser. III, Herb. No. 637); 2. UW(F), Russell St., Oatley, New South Wales, Australia, 12.IX.1979, B.Kendrick.

Known distribution: Australia, Portugal.

The fungus is not associated with leaf spots.

Costa & Camara (1955) described *Bartalinia muehlenbeckiae* occurring on **Muehlenbeckia platyclados* from Portugal. Although I have not examined the type specimen of *B. muehlenbeckiae*, the qualitative and quantitative characters emphasized in their description and illustration of the fungus suggest that it is identical with *Pestalotia heteromorpha*.

The synoptic plate (Fig. 12) highlights the diagnostic differences between the anamorph-genera: *Bartalinia*, *Pestalotiopsis* and *Pestalozzina*. It is clear that *Pestalotia heteromorpha* has greater affinity with *Pestalozzina* than with *Pestalotiopsis* or *Bartalinia*. However, before a proper redisposition can be made, the status of *Pestalozzina* needs to be clarified.

The name *Pestalozzina* was introduced by Saccardo (1884) as a subgenus of *Pestalotia*, with *P. unicolor*, *P. laurina* and *P. callunae* assigned to it. Subsequently (1892) he added *Pestalotia fautreyi* Karst. & Roumeg. as the fourth species of the subgenus. Sorauer (1894) inadvertently introduced a nomenclatural complexity when he published the binomial *Pestalozzina soraueriana* Sacc., though the name *Pestalozzina* had not been proposed at the generic level at that time. Saccardo (1895) elevated *Pestalozzina* to generic rank and added *Pestalozzina soraueriana* Sacc. as well as *P. rollandi* Fautr. to the genus; *P. callunae* was omitted from the genus. Höhnel (1925) accepted *Pestalozzina* as validly published and *P. unicolor* Berk. & Curt. as the lectotype. Guba (1961) redisposed *P. laurina* and *P. fautreyi* in *Hyalotia* Guba, and accepted Höhnel's (1925) redispositions of *P. rollandi* and *P. soraueriana* as synonyms of *Strasseria geniculata* and *Mastigosporium album* respectively.

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*See foot-note on p. 203.

In an attempt to resolve the nomenclatural complexity associated with the name *Pestalozzina*, Sutton (1977) considered two alternatives: either (1) to regard 1894 as the first publication date for *Pestalozzina* at generic rank by Saccardo apud Sorauer (1894); or (2) to consider Saccardo's 1895 publication of *Pestalozzina* as the start date for the name. He (op. cit.) preferred the first alternative. If this choice is accepted, *Pestalozzina* becomes a synonym of *Mastigosporium* Reiss, since *P. soraueriana* is congeneric with *Mastigosporium album* (Höhnel 1925, Hughes 1951), and a new name is needed for the taxa so far considered under *Pestalozzina*.

I prefer the second alternative, since such a choice will allow retention of the name *Pestalozzina* in the original sense intended by Saccardo (1895). *Pestalozzina soraueriana* Sacc. apud Sorauer is best considered a '*lapsus calamus*'. The correct nomenclator for *Pestalotia heteromorpha* is as follows:

Pestalozzina heteromorpha (Thüm.) **comb. nov.**
≡ *Pestalotia heteromorpha* Thüm., Inst. Rev. Sci. Litt. Coimbra, ser. 3, 28: 575, (1880) 1881.
≡ *Bartalinia muehlenbeckiae* Costa & Camara, Agron. Lusit. 17: 162, 1955.

Acknowledgments

I thank the curators at BPI and LPS for the loan of the specimens examined in this study. I am deeply indebted to Prof. B. Kendrick, Department of Biology, University of Waterloo, and Dr. Amy Rossman, Mycology Laboratory, Beltsville, Md., U.S.A. for critical reviews of this manuscript. The Natural Sciences and Engineering Research Council of Canada provided financial support for this research in the form of an operating grant to Prof. Kendrick.

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Saccardo, P.A. 1884. Sylloge Fungorum. 3: 1-860.
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MYCOTAXON

Vol. XXVI, pp. 211-222 July-September 1986

REDISPOSALS AND REDESCRIPTIONS IN THE **MONOCHAETIA-SEIRIDIUM, PESTALOTIA-PESTALOTIOPSIS** COMPLEXES. VII. PESTALOTIA CITRINA, P. MAURA and PESTALOTIOPSIS UVICOLA

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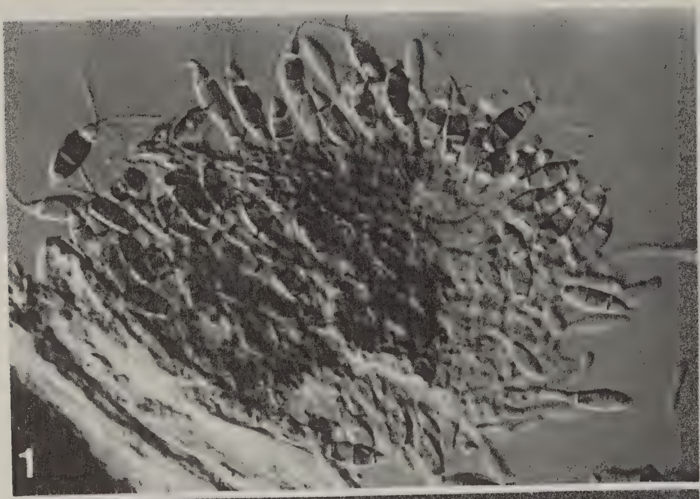
A new combination in Pestalotiopsis is proposed for Pestalotia citrina. Pestalotia maura, is similar to P. gibberosa; both are congeneric with Pestalotiopsis maculans. Pestalotipsis uvicola is redescribed from the type specimen.

9. Pestalotia citrina McAlpine, Proc. Linn. Soc., N.S.W., ser. I, 28: 556, 1903.

On twigs of Lobelia gibbosa, Sandringham, Victoria, Australia, XII.1902, C.French Jr. (type in VPRI 2202-- McAlpine Herb. 178/03).

Guba (1961) appears to have reproduced the original description without indicating whether he had studied the type specimen. He retained the fungus in his section 'quadriloculatae' of Pestalotia.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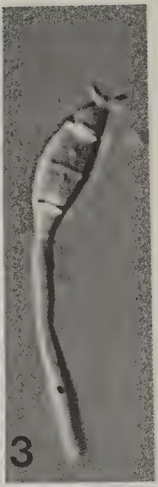
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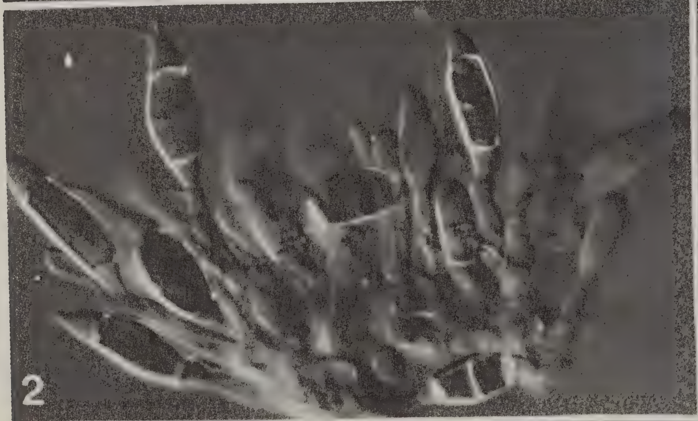
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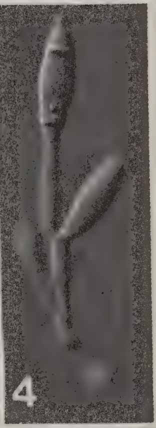
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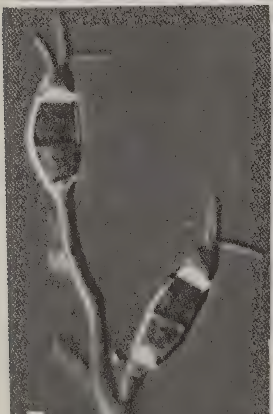
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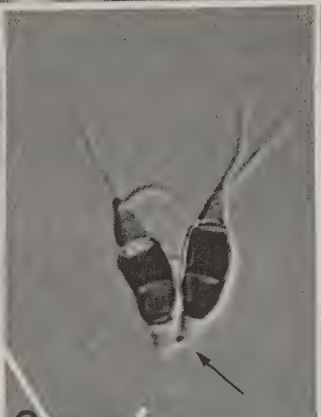
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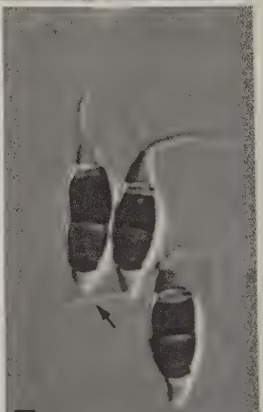
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Figs. 1-7. Pestalotiopsis citrina ex type in VPRI (all under Nomarski-interference phase optics). Fig. 1. Squash mount of a conidioma. X 480. Figs. 2-5. Conidiophores and conidiogenous cells with developing conidia. X 800. Figs. 6 & 7. Mature conidia. X 800. (Arrows mark basal appendages).

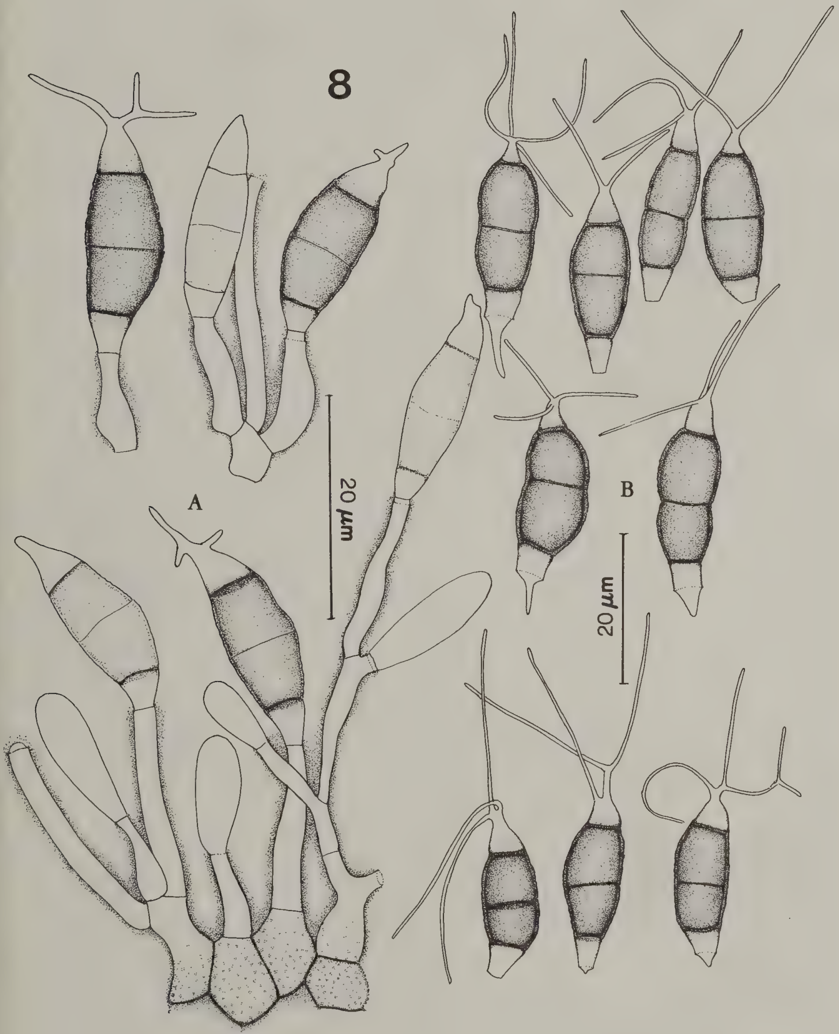

Fig. 8. Pestalotiopsis citrina ex type in VPRI. A. Conidiophores and conidiogenous cells. B. Mature conidia.

The specimen is now depauperate after a single conidioma on the specimen was used up for study. Satisfactory transverse sections of the conidioma could not be obtained. Hence, details of the nature and anatomy of conidioma and the arrangement of the conidiophores in the conidioma could not be ascertained. Pestalotia citrina is congeneric with Pestalotiopsis maculans (Cda.) Nag Raj and differs from Pestalotiopsis besseyii (Guba) Nag Raj, the only other 4-celled species known so far, in possessing longer and wider conidia, unequal, but longer, median cells and longer apical appendages. The following description and the illustrations in Figs. 1-8 are based on slide preparations derived from the single conidioma observed on the specimen.

Pestalotiopsis citrina (McAlp.) **comb. nov.**
≡ Pestalotia citrina McAlp., Proc. Linn. Soc., N.S.W., ser. I, 28: 556, 1903.

Caulicolous and corticolous. Conidiomata stromatic, scattered to gregarious, subperidermal in origin, applanate, brown, glabrous, dehiscing by a rupture in the upper wall; cells of the stroma thick-walled, pale brown and encrusted. Conidiophores 0-1-septate, simple or irregularly branched, hyaline, smooth-walled, up to 33 μm long, invested in mucus. Conidiogenous cells phialidic, lageniform, subcylindrical to cylindrical, discrete or integrated, hyaline, smooth-walled, 8.5-18 X 1.5-2.5 ($\bar{x}$ = 13.5 X 2) μm, with up to 2 percurrent proliferations. Conidia blastic-phialidic, fusiform, 3-septate, 19-26 X 7-9 ($\bar{x}$ = 22.5 X 8) μm, bearing appendages; basal cell obconic with a truncate base and minute marginal

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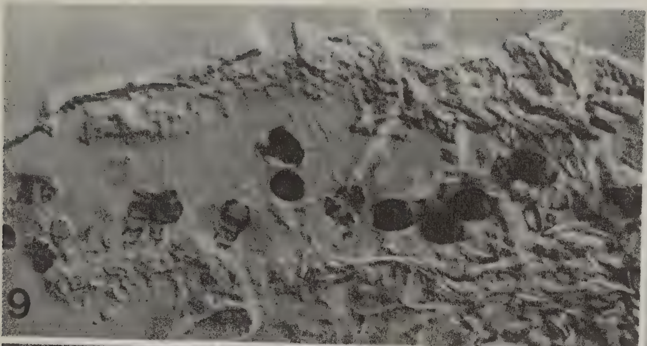
Figs. 9-16. Pestalotiopsis sp. ex type of Pestalotia maura in NY (Figs. 13 & 16 under bright field illumination; rest under Nomarski-interference phase optics). Fig. 9. V.s. of conidioma. X 480. Figs. 10 & 11. Conidiogenous cells with developing conidia. X 2000 (arrowheads mark percurrent proliferations). Figs. 12-16. Mature conidia. Figs. 12, 14,16: X 800; fig. 15: X 1600.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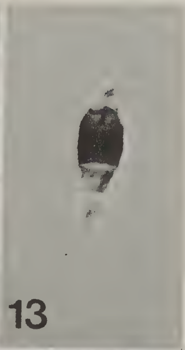
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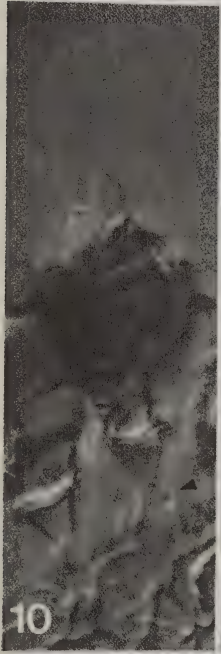
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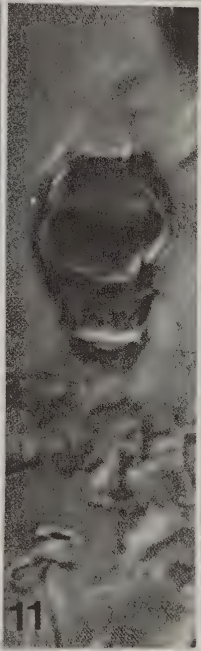
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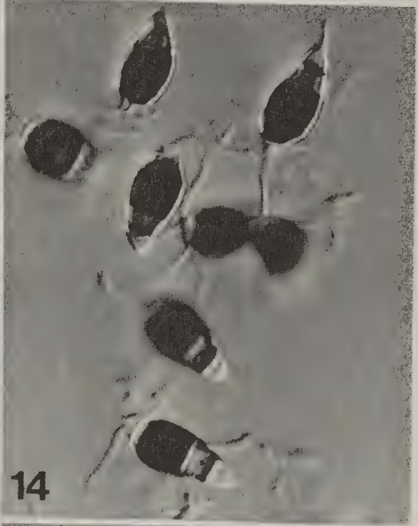
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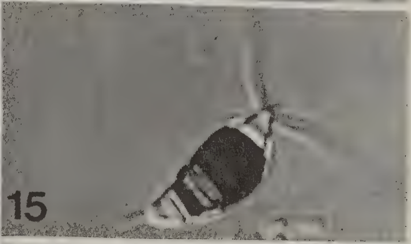
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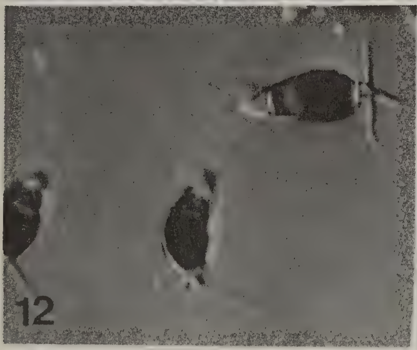
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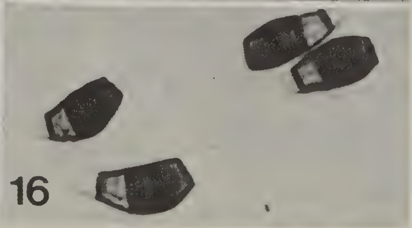
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frills, hyaline below, subhyaline above, smooth-walled, 3-5 ($\bar{x}$ = 4) µm long; 2 median cells subcylindrical to doliiform, thick-walled and minutely verruculose or rugose, pale brown and concolorous, more or less equal (second cell from base 5-9 ($\bar{x}$ = 7) µm long, third cell from base 6.5-9 ($\bar{x}$ = 7.7) µm long), together 12-17 ($\bar{x}$ = 14.5) µm long; apical cell conic, subhyaline below, hyaline above, thin-walled, smooth, (2-)3-5 ($\bar{x}$ = 4) µm long; apical appendages 2-4, mostly 3, tubular, simple, occasionally one of them forked or irregularly branched, attenuated and slender, flexuous, in an apical crest but each inserted at a different locus on the apical cell, (6.5-)10-25 ($\bar{x}$ = 17.5) µm long; basal appendage often absent; if present, centric, tubular, attenuated, unbranched, up to 4.5 um long; mean conidium length/width ratio = 2.8:1.

10. Pestalotia maura Ellis & Everhart, Jour. Mycol. 4: 123, 1888.

On leaves of Psychotria rufescens, Halifax River, Florida, May, A.H.Commons No. 881 (type in NY).

On the basis of the original description, Guba (1961) accepted P. maura in his section 'quadriloculatae' and more or less repeated the description published by Saccardo (1892). He also indicated that the type specimen in NY was sterile.

My study of the type specimen, however, yielded information not found by Guba. The specimen consists of a single leaf with many irregular, copper coloured leaf spots with abundant material of a Phyllosticta sp. A careful scrutiny of spots revealed a single epiphyllous conidioma that was used to obtain sections and squash mounts. However, because of the paucity of the material and the consequent lack of satisfactory sections, the anatomical details of the conidioma could not be ascertained. The salient morphological features of the fungus are illustrated in Figs. 9-17, and a partial description is given below:

Conidiophores reduced to conidiogenous cells, invested in mucus. Conidiogenous cells phialidic, ampulliform to lageniform, hyaline, smooth, 5-7 X 2.5-4 ($\bar{x}$ = 6 X 3.3) µm, with a few percurrent proliferations. Conidia blastic-phialidic, broadly fusiform to obovoid, 4-septate, 18.5-20.5 X 7-10 µm, bearing appendages;

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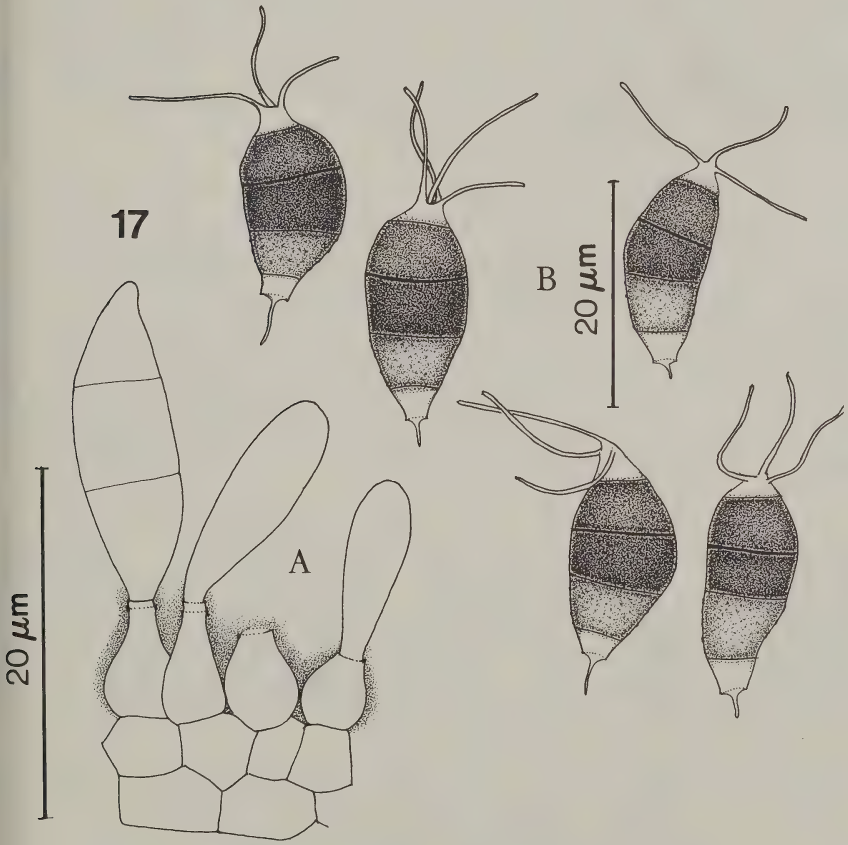


Fig. 17. Pestalotiopsis sp. ex type of Pestalotia maura in NY. A. Conidiogenous cells with developing conidia. B. Mature conidia.

basal cell obconic with a narrow truncate base, subhyaline above, hyaline below, smooth, 2.5-4 ($\bar{x}$ = 3.2) µm long; 3 median cells, short terete, brown but versicoloured with the third and fourth cells from the base darker than the second cell from the base, thick-walled, verruculose, together 13.5-14.5 ($\bar{x}$ = 14) µm long (second and fourth cells from base 4-5 ($\bar{x}$ = 4.5) µm long; central cell 4.5-5 ($\bar{x}$ = 4.7) µm long); apical cell conic, subhyaline in the lower part, hyaline above, smooth, 2-3 ($\bar{x}$ = 2.5) µm long; apical appendages tubular, 3-4, arising at different loci but closely aggregated in a crest, filiform, flexuous, 8-13 ($\bar{x}$ = 11) µm long; basal appendage, when present, single, filiform or attenuated, centric, 1-4 ($\bar{x}$ = 2.5) µm long; mean conidium length/width ratio = 2.2:1.

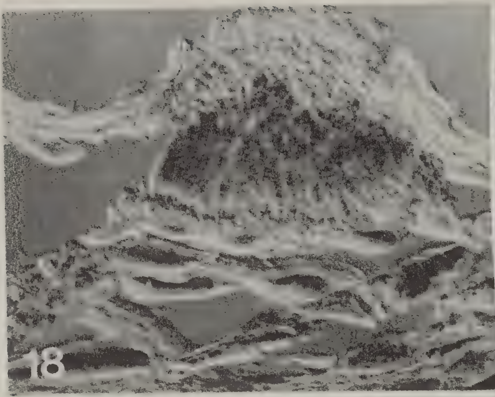
A characteristic feature of the conidia of this fungus is that the septum between the third and fourth cells from the base is thicker and darker than the other septa. The morphological features and the dimensions reported above invite comparison with _Pestalotia gibberosa_ Sacc., which should be regarded as a species of _Pestalotiopsis_. However, a nomenclatural decision concerning _P. maura_ must await a critical reappraisal of _P. gibberosa_.

BPI, FH and NY also house a few other collections (on _Persea carolinensis_, _Quercus virens_ and _Q. palustris_), all under the name _P. maura_. A study of these specimens have confirmed the validity of Guba's (1961) conclusion that these belong in other species of _Pestalotiopsis_ (Guba listed them as '_Pestalotia_').

11. Pestalotiopsis uvicola (Spegazzini) Bissett,
Can. J. Bot. 60: 2572, 1982.
≡ _Pestalotia uvicola_ Spegazzini,
Riv. Viticoltura Enologia Ital. 2: 340, 1878.

Bissett (1982) proposed the new combination for *Pestalotia uvicola* without giving a revised description and illustration of the taxon. This means that mycologists still have Guba's outdated account as a guide to identify the species. The following account and illustrations (Figs. 18-25), derived from a study of the type specimen, will remedy the situation.

Fructicolous. *Conidiomata* stromatic, pycnidioid, scattered to gregarious and often confluent, innate-erumpent, globose to broadly conical in sectional view, 200-300 µm wide, 140-200 µm deep, unilocular, glabrous, straw-coloured with a dark centre, appearing gelatinous when rehydrated in 2% aqueous KOH; wall and basal tissue 10-20 µm thick, of 'textura globulosa', cells thick-walled and hyaline, becoming lenticular and up to 50 µm thick in the area of dehiscence. *Conidiophores* arising at the base and part way up the side walls of the conidioma, reduced to conidiogenous cells, or more often septate, simple or irregularly branched, hyaline, smooth, up to 40 µm long, invested in mucus. *Conidiogenous cells* phialidic, ampulliform or lageniform, (7-9 X 3-4.5 ($\bar{x}$ = 8 X 3.7) µm) to subcylindrical (up to 15 µm long and 2.5 µm wide), proliferating percurrently 2-3 times. *Conidia* blastic-phialidic, fusiform to narrow ellipsoid, 4-septate, 18-25 X 5.5-7.5 ($\bar{x}$ = 21.5 X 6.5) µm, bearing appendages; basal cell obconic with a truncate base, hyaline below, subhyaline above, 3-5 ($\bar{x}$ = 4) µm long; 3 median cells short cylindrical, pale brown and concolorous, septa and periclinal walls darker than the rest of the cell area, wall rugose with or without constrictions at the septa, together (12.5-)14-16 ($\bar{x}$ = 15) µm long (second cell from the base 5-6 ($\bar{x}$ = 5.5) µm; central cell 4-5 ($\bar{x}$ = 4.5) µm; fourth cell from the base 3.5-5.5 ($\bar{x}$ = 4.5) µm); apical cell conical, hyaline, 2.5-3.5 ($\bar{x}$ = 3) µm long; appendages tubular, unbranched, attenuated, flexuous; apical appendages 2-4, with independent loci of origin along the upper half of the apical cell, often forming a closely aggregated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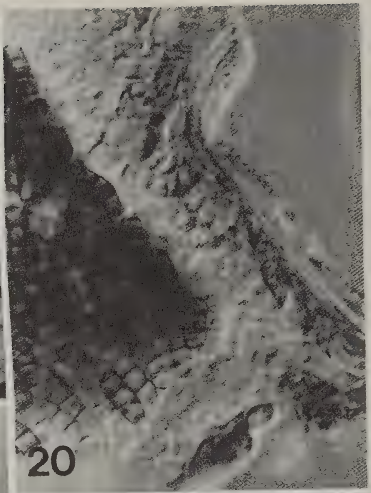
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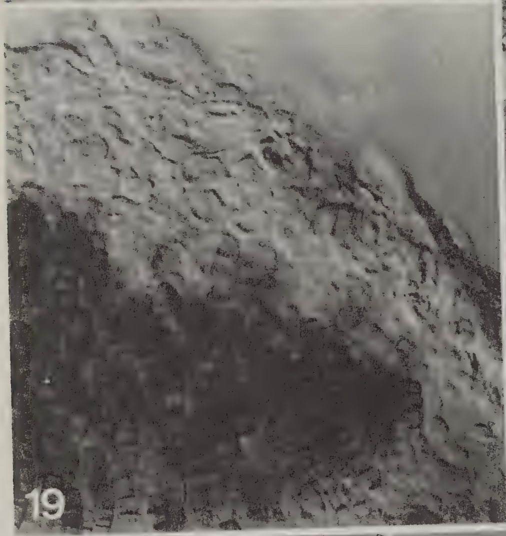
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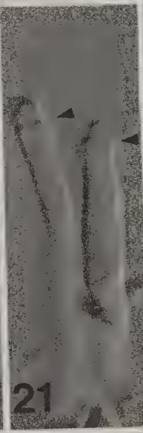
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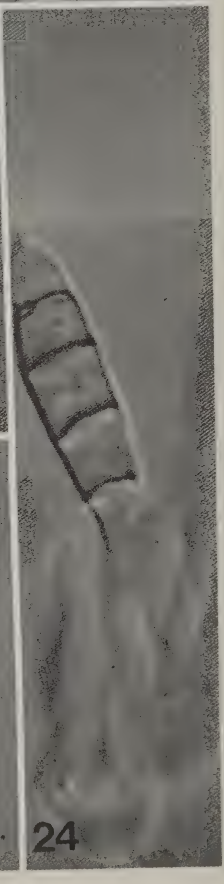
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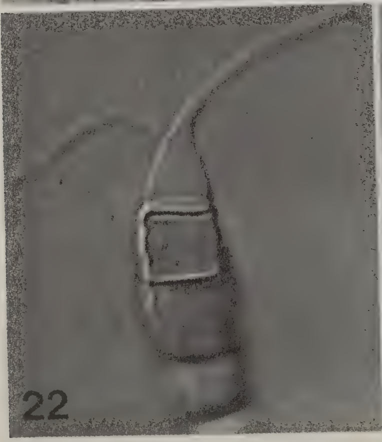
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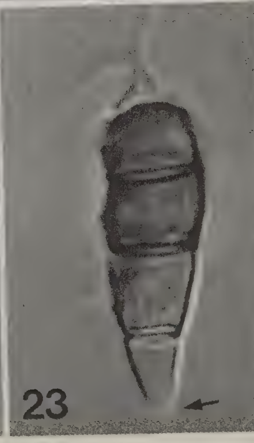
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Figs. 18-24. Pestalotiopsis uvicola ex type in LPS (All under Nomarski interference phase optics). Fig. 18. V.s. conidioma. ca X 192. Figs. 19 & 20. Enlarged sectional view of a conidioma to show tissue details. ca X 480. Figs. 21 & 24. Conidiogenous cells and developing conidium. X 2000 (arrowheads in fig. 21 mark percurrent proliferations). Figs. 22 & 23. Mature conidia (note wall verrucosities and the basal appendage marked by arrow). X 2000.

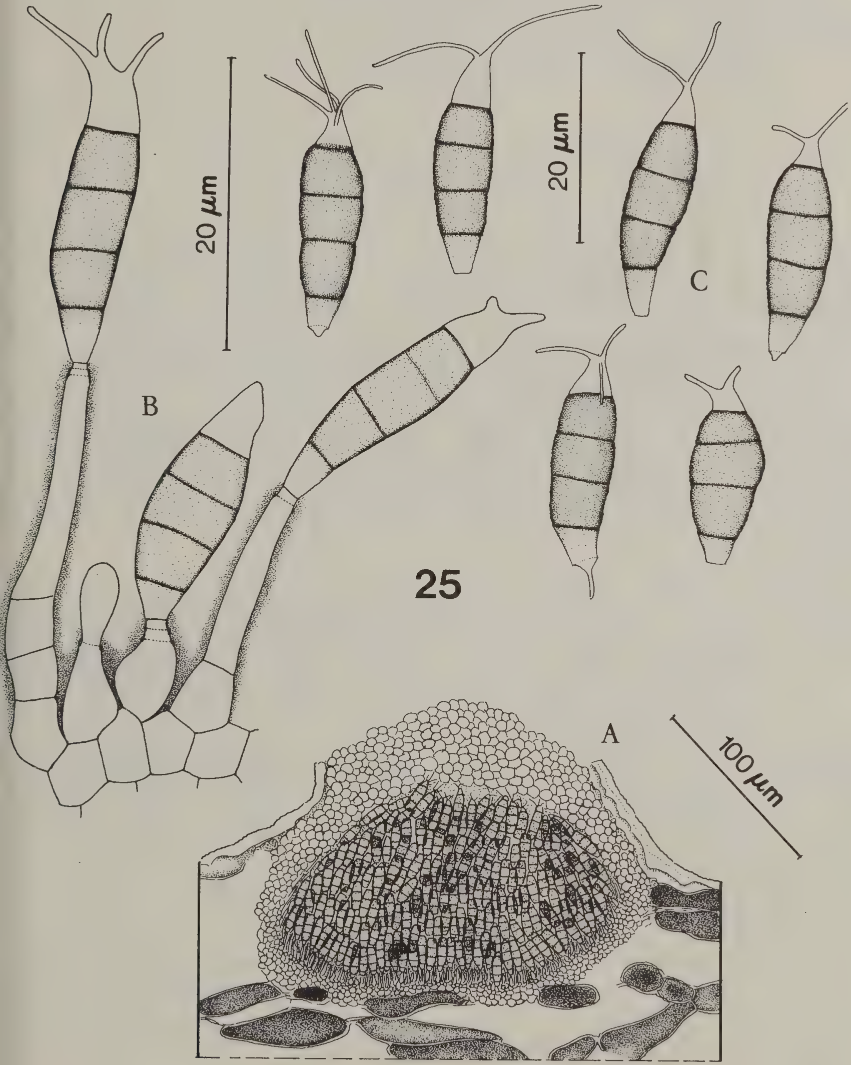

Fig. 25. Pestalotiopsis uvicola ex type in LPS. A. V.s. conidioma. B. Conidiophores and conidiogenous cells with developing conidia. C. Mature conidia.

crest, 4-14 ($\bar{x}$ = 9) µm long; basal appendage (when present) single, unbranched, attenuated, centric, up to 3 µm long; mean conidium length/width ratio = 3.3:1.

Habitat: On Vitis vinifera fruit.

Specimen examined: LPS 11865 (Holotype), Conegliano, Italy, C.Spegazzini.

Known distribution: Italy.

Teleomorph: Unknown.

Acknowledgments

I thank the curators at BPI, LPS, NY and VPRI for the loan of the specimens examined in this study. I am deeply indebted to Prof. B. Kendrick, Department of Biology, University of Waterloo, and Dr. Amy Rossman, Mycology Laboratory, Beltsville, Md., U.S.A. for critical reviews of this manuscript. The Natural Sciences and Engineering Research Council of Canada provided financial support for this research in the form of an operating grant to Prof. Kendrick.

Bissett, J. 1982. Pestalotiopsis menezesiana on greenhouse plantings of Cissus rhombifolia with notes on related fungi occurring on Vitaceae. Can. J. Bot. 60: 2570-2574.

Guba, E.F. 1961. Monograph of Monochaetia and Pestalotia. Harvard Univ. Press, Cambridge, Mass., U.S.A. 342 pp.

Saccardo, P. A. 1892. Sylloge Fungorum. 10: 1-964.

MYCOTAXON

Vol. XXVI, pp. 223-234 July-September 1986

CULTURAL AND CYTOLOGICAL STUDIES IN THE GENUS *HYMENOCHAETE* LEV.[1]

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SUMMARY

The morphology based on the methodology proposed by Nobles (1948, 1958, 1965),and the cytology of polyspermic cultures of *H. cervina* Berk., *H. cinnamomea* (Pers.) Bres., *H. leonina* Berk. & Curt., *H. luteo-badia* (Fr.) Höehn. & Litsch., *H. pinnatifida* Burt and *H. sallei* Berk. & Curt., were studied. Codes and illustrations for those species are supplied, and we propose the utilization of code number 28*d* to describe the presence of dendrophyses in culture.

The very few data available on the behavior of the genus *Hymenochaete* Lév. in culture were mainly the result of studies by Kühner (1950), Nobles (*op. cit.*), Boidin (1958), Stalpers (1978), Léger *et al.* (1983) and more recently Boidin *et al.* (1984).

The study of cultures of *H. cervina* Berk. & Curt., *H. cinnamomea* (Pers.) Bres., *H. leonina* Berk. & Curt., *H. luteo-badia* (Fr.) Höehn. & Litsch., *H. pinnatifida* Burt and *H. sallei* Berk. & Curt., of broad distribution in the Northeast area of Argentina (Job, 1985a) and Southwestern Brazil (Job, 1985b), adds more information on this genus.

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[1] Work carried out as part of the research project on xylophilous fungi of Argentina, subsidized by the Argentine National Research Council (CONICET). Publication N°17 of the PRHIDEB.

[2] Fellow of the above Council.

MATERIAL AND METHODS

The polyspore cultures were obtained from spore-print material. The study of the morphology was carried out based on Nobles' methodology (*op. cit.*) and includes the code using the added numbers mentioned by Boidin & Lanquetin (1983).

The medium employed was:

a) Growth medium: malt agar (Nobles, 1948)
b) Oxidase reaction medium: i- gallic acid agar (Davidson *et. al.*, 1938)
ii- tannic acid agar (idem.)
iii- guaiacol 2% (Boidin, 1958:40)
iv- paracresol (idem. , 1958:41)
v- tyrosine (idem. , 1958:41)

The reaction intensity and the rate of the mycelium growth are given as described by Davidson *et al.* (*op. cit.*). The colors of the mycelium are described based on Maerz & Paul (1930).

For the cytological study the technique mentioned by Boidin (1958) has been followed. The cultures were grown under a collodion film, and were fixed by a saturated solution of Cl_2Hg and glacial acetic acid, finally being colored with slow giemsa.

RESULTS

1- *H. cervina* Berk. & Curt.

Macroscopic characters: growth very slow, reaching 6,5 - 7,5 cm after 6 weeks. Mat subarachnoid, hyaline at first, finally gold brown (pl. 14 F 12) after the 4th. week (Fig. 1). Margin regular, subarachnoid, appressed. Reverse slightly changed to brown near the inoculum. Odor absent.
Reactions:
guaiacol 2%: + +, no growth
gallic ac.: + + +, no growth
tannic ac.: + +, no growth
tyrosine: -, no growth
paracresol: -, no growth

Microscopic characters: margin formed by generative hyphae of 2 types: 1- twisted, 3 - 3,6 µm diam, afibulate, thin-walled, sparsely septate (Fig. 2) and 2- straight, afibulate 3 - 4,2 µm diam. Aerial hyphae thin-walled generative hyphae 2 - 5,8 µm diam, straight or with zigzag walls (Fig. 3). Hyphae submerged with kidney shaped characteristic protuberances, which begin to be observed after the second week, first in the margin and later in all the mycelium (Fig. 4). Brown hyphae are observed; these have broad walls which form a compact mesh and resulting in a plectenchymatose tissue (Fig. 5).
Cytological studies: cells binucleate, more rarely uni or trinucleate (Fig. 6).
Code: 2*a*, 6, 11, 22, 32, 37, 39, 47, 54, 64.

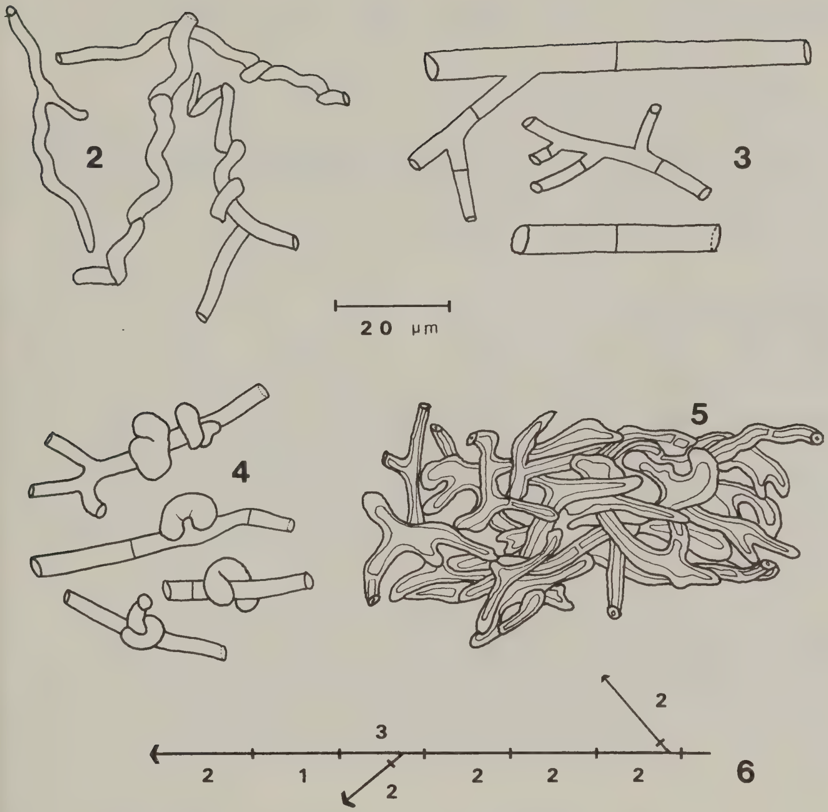

Fig. 2-6: *H. cervina* 2- advance mycelium generative hyphae 3- mycelial layer hyphae 4- submerged hyphae with kidney shaped protuberances 5- plectenchymatic tissue 6- distribution of the nuclei in the polyspermic culture BAFC N°1167.

Culture studied: BAFC N°1167 = Argentina, Misiones, Parque Nacional Iguazú; leg. Job & Rajchenberg; 6-IV-1984 (BAFC N° 30257).*

Remarks: the characteristic of forming generative hyphae with kidney shaped protuberances, that resemble incomplete clamps conections, may be a specific character although not constant, since it has been observed in only one of three cultures studied of H. berteroi Pat. (Léger, personal communication).

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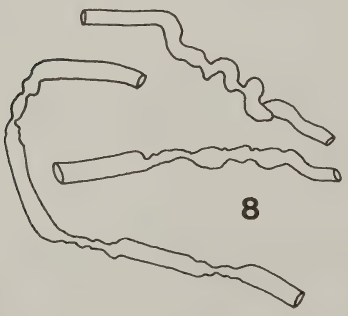
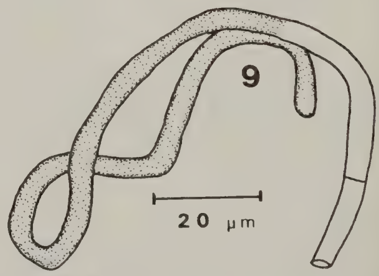
*The numbers in parentheses are herbarium voucher specimens.

2- H. cinnamomea (Pers.) Bres.

Macroscopic characters: growth slow, covering the plate at the end of the 5th. week. Mycelial layer of texture ranging from felty to cottony, white during the first weeks, later turning yellow ochre (Fox antique pl. 14 K 8). Margin elevated, hyaline, regular, subfelty (Fig. 7). Reverse changed homogeneously to dark brown at the end of the study. Odor sweet.
Reactions:
guaiacol 2%: + + + +, no growth
gallic ac.: + + + +, no growth   tyrosine: -, 0,5 cm
tannic ac.: + + +, 0,8 cm   paracresol: -, 0,5 cm

Microscopic characters: the advance mycelium formed by 1,7 - 3,7 µm diam generative hyphae with few branches, thin walls, afibulate, with numerous constrictions 0,8 - 1,6 µm diam (Fig. 8). Mycelial layer formed by regulary septate, generative hyphae, 2 - 6,8 µm diam, with thin hyaline walls, some of them constricted to 1,2 - 3,4 µm diam, and generative hyphae with amber like oily contents 2,8 - 5,3 um diam (Fig. 9). From the third week on, brown generative hyphae with irregular nodules and short branches form in the central zone of the culture, with slightly thickened walls, that form a scarce plectenchymatic tissue (Fig. 10). Submerged mycelium composed of distorted generative hyphae 2,3 - 3,8 µm diam, hyaline, thin walled, lacking clamps.
Cytological studies: cells coenocytic, specially the terminal ones with variation of 26 to 58 nuclei (Fig. 11).





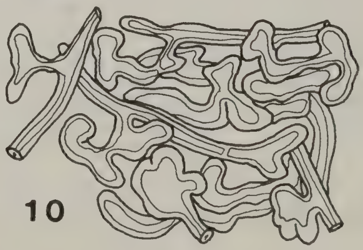


Fig. 8-10: H. cinnamomea 8- advance mycelium generative hyphae 9- generative hyphae with amber-like oily contents 10- plectenchymatic tissue.

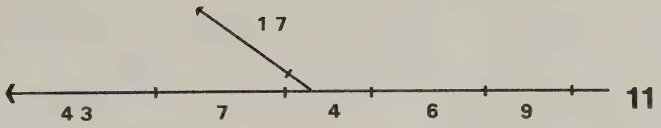


Fig. 11: H. cinnamomea distribution of the nuclei in the polyspermic culture BAFC N°1164.

Code: 2a, 6, 7, 11, 32, 37, 39, 45, 50, 54.
Culture studied: BAFC N°1164 = Argentina, Misiones, Parque Nacional Iguazú; leg. Wright, Rajchenberg & Job; 8-IV-1984 (BAFC N°30255).
Remarks: H. cinnamomea presents a growth pattern in culture very similar to that of H. corrugata (Nobles, 1950) and of H. sallei. It differs from these at the macroscopic level, by a slower growth and microscopically by having an inconspicuous plectenchymatic tissue.

Cytologically the studied culture presents coenocytic cells. This differs from the observations of Boidin et al. (1984) who found dikaryotic cells.

3- H. leonina Berk. & Curt.

Macroscopic characters: growth very slow, reaching 7 - 8 cm after six weeks. Mycelial layer hyaline, subarachnoid, with irregular yellow zones (pl. 12 L 7) near the inoculum (Fig. 12). Margin irregular, subarachnoid, appressed to the substrate. Reverse changed to brown in the area up to 35 mm from the inoculum. Odor of antiseptic.
Reactions:
guaiacol 2%: + + +, no growth
tannic ac.: + + + +, tr.   paracresol: -, tr.
gallic ac.: + + + +, tr.   tyrosine: -, 0,6 cm

Microscopic characters: advance mycelium formed by regulary branched, afibulate hyphae, 3,5 - 5 µm diam, and branches 1,5 - 2,5 µm diam (Fig. 13). Mycelial layer formed by hyphae similar to the advance mycelium, very few with bulbils. Submerged mycelium characterized by very short branched generative hyphae (Fig. 14). Crystals present in the agar.
Cytological studies: cells binucleate, more rarely with uninucleate ones (Fig. 15).
Code: 2a, 6, 7, (22), 32, 37, 39, 47, 50, 54, 64.
Culture studied: BAFC N°1152 = Argentina, Misiones, Parque Nacional Iguazú; leg. Job; 8-IV-1984 (BAFC N°30251).
Remarks: H. leonina has distinctive cultural characteristics in the genus. Macroscopically it presents a subarachnoid texture, and a pale mycelial layer. Microscopically it does not form a dense hyphal weft, like other species studied in this genus.

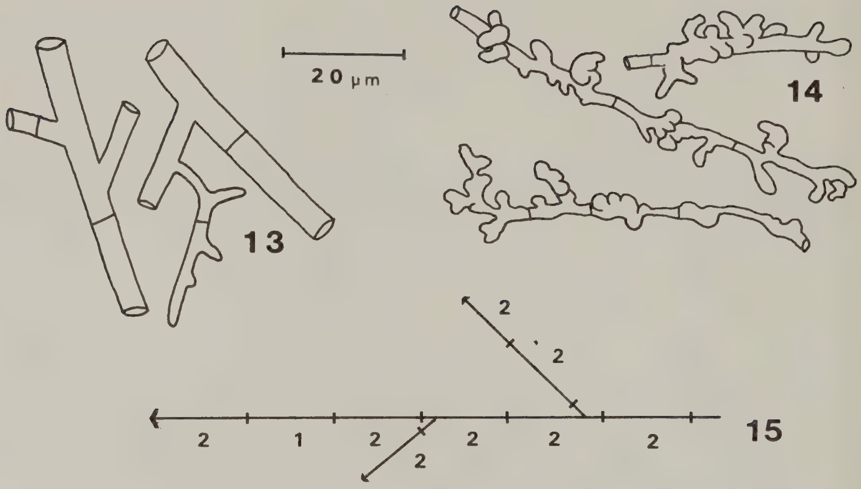


Fig. 13-15: H. leonina 13- advance mycelium generative hyphae 14- submerged hyphae with very short branches 15- distribution of the nuclei in the polyspermic culture BAFC N°1152.

4- H. luteo-badia (Fr.) Höehn. & Litsch.

Macroscopic characters: growth very slow, reaching 5 - 5,6 cm by the sixth week. Mycelial layer hyaline at the beginning turning brown (Gold Brown pl. 14 F 12) after the fourth week with dark zones (Burnt umber pl. 15 A 12). Texture subfelty. Advance mycelium submerged, irregular, soft, grey (Fig. 16). Culture medium changed to brown in the area around and under the inoculum. Odor absent.

Reactions:

gallic ac.: + + + (+), tr.	tyrosine: -, no growth
tannic ac.: + + (+), tr.	paracresol: -, no growth
guaiacol 2%: + + (+), no growth	

Macroscopic characters: aerial mycelium formed by afibulate, branched, thin walled, generative hyphae of variable diameter, 1,8 - 7 µm (Fig. 17). Mycelial layer formed by hyphae similar to those of the advance mycelium, some with numerous oily contents (Fig. 18). In correlation with the darker zones of the mycelial layer we observed the presence of a plectenchymatic tissue. Numerous crystals present near the inoculum.
Cytological studies: cells binucleate, rarely uni or trinucleate (Fig. 19).
Code: 2a, 6, 11, 32, 37, 39, 47, 54, 64.
Culture studied: BAFC N°438 = Argentina, Misiones, Parque Nacional Iguazú; leg. Job; 22-IX-1984 (BAFC N°30289).
Remarks: H. luteo-badia has a growth pattern very similar to that of H. cervina, differing from it microscopically by lacking bulbils, and macroscopically by its irregular margin.

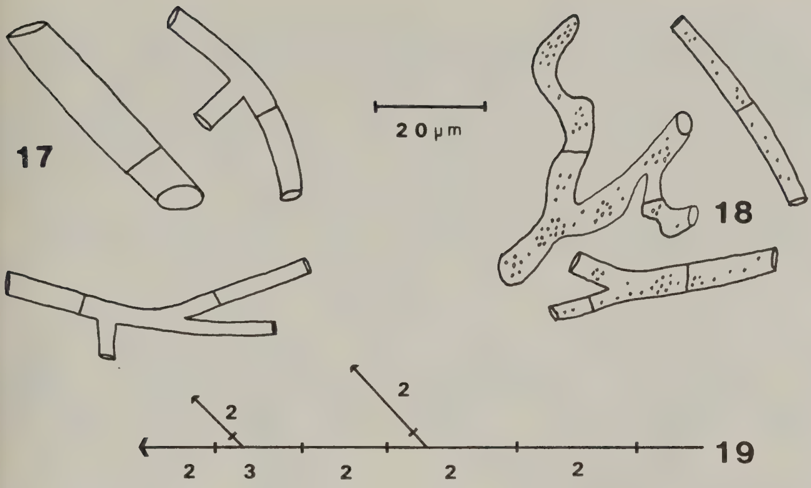


Fig. 17-19: *H. luteo-badia* 17- generative hyphae of the aerial mycelium 18- generative hyphae of the advance mycelium with numerous oily contents 19- distribution of the nuclei in the polyspermic culture BAFC N°438.

5- *H. pinnatifida* Burt

Macroscopic characters: growth very slow, reaching 6 - 7 cm after 6 weeks. Mycelial layer hyaline at the beginning, then golden brown (Cognac pl. 14 J 11 to Soudan pl. 14 L 12). Texture initially felty, turning velvety after the second week. Advance mycelium submerged, forming a wide dark zone around the aerial mycelium (Fig. 20). Culture medium changed intensely to brown in all the plate. Odor lightly sweet.
Reactions:
gallic ac.: + + + +, tr.
tannic ac.: + + +, tr.
guaiacol 2%: + + + +, no growth
tyrosine: -, no growth
paracresol: -, no growth

Microscopic characters: aerial mycelium formed by generative hyphae, branched, afibulate, without constrictions 3 - 5,6 µm diam, densely interwoven, numerous more or less branched, pigmented hyphae, with walls regulary thickened, fibrous hyphae 3 - 4,8 µm diam (Fig. 21), which form a dense trama. Brown, thin-walled dendrophyses regulary present in the culture (Fig. 22). Advance mycelium formed by generative hyphae, with enlargements and protuberances. Crystals free in the agar.
Cytological studied: cells coenocytic, with variation of 3 to 7 nuclei (Fig. 23).
Code: 2a, 6, 8, 28d, 32, 37, 39, 47, 50, 54.
Culture studied: BAFC N°640 = Argentina, Misiones, Parque Nacional Iguazú; leg. Job; 23-IX-1984 (BAFC N°30287), and

BAFC N°702 = *ibid*; leg. Job; 8-IV-1984 (BAFC N°30326).
Remarks: Boidin & Lanquetin (1983) proposed the utilization of the code number 28 for the asterophyses in culture. But Burdsall and Nakasone (1981) have used previously this code number 28 for the capitulate spines of *Mycoacia meridionalis*. So we propose now -in agreement with Boidin and Lanquetin- that the code number 28*a* should be used for the asterophyses and the code number 28*d* for the dendrophyses.

H. pinnatifida is well characterized by the presence of *fibrous hyphae* and dendrophyses, structures not found up to the present in cultures of this genus.

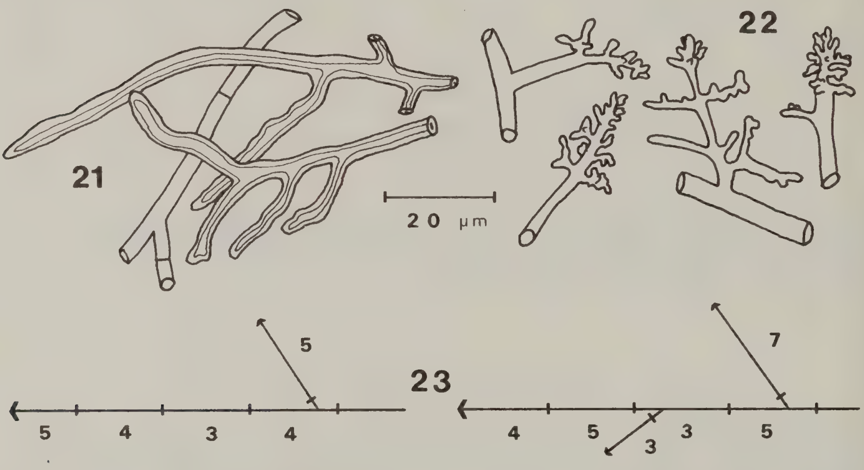


Fig. 21-23: *H. pinnatifida* 21- fibrous and generative hyphae 22- dendrophyses 23- distribution of the nuclei in the polyspermic cultures BAFC N°640 and BAFC N°702.

6- *H. sallei* Berk. & Curt.

Macroscopic characters: growth rapid, covering the plate during the 3 rd week. Mycelial layer, felted, hyaline at the beginning, turning ochre yellow (pl. 11 L 8) with more densely felty zones slightly orange tinted(pl. 3 B 12). Margin white, raised, felty, regular (Fig. 24). Reverse turning dark brown in the central zone of the culture after the third week. Odor sweet.
Reactions:
gallic ac.: + + + +, 0,6 cm
tannic ac.: + + + +, 0,4 cm
guaiacol 2%: + + +, no growth
tyrosine: -, no growth
paracresol: -, no growth

Microscopic characters: advance margin formed by afibulate, much branched generative hyphae, 2 - 3,6 µm diam (Fig. 25). Felty layer and inoculum formed by afibulate regulary bran-

ched generative hyphae, 4,3 - 7,5 µm diam, with walls slightly thickened and branches 2 - 3,2 µm diam (Fig. 26). Crystals free in the agar. Dense zones of the mycelial layer formed by brown hyphae with thickened walls, densely interwoven, which originate a plectenchymatic tissue (Fig. 27). Cytological studies: cells coenocytic, with variation of 6 to 14 nuclei (Fig. 28).
Code: 2*a*, 6, 11, 32, 37, 39, 43, 50, 54.
Culture studied: BAFC N°599 = Argentina, Misiones, Parque Nacional Iguazú; leg. Job; 23-IX-1984 (BAFC N°30283).
Remarks: *H. sallei* has a rate and type of growth in culture similar to that of *H. corrugata* (Nobles, 1958). Microscopically both species present similar structures requiring their differentiation to be made at the microscopic level since *H. sallei* does not produce a bleaching of the culture medium and has its mycelial layer slightly tinged with orange. Boidin *et al.* (1984) have observed a slower rate of growth for this species.

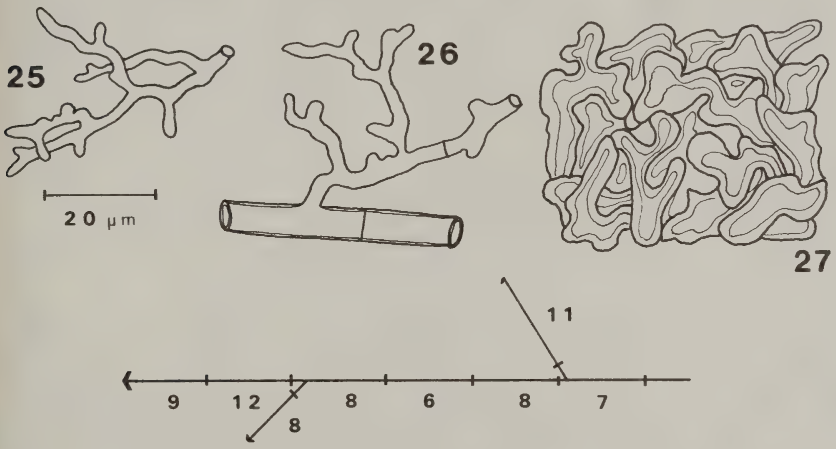


Fig. 25-28: *H. sallei* 25-advance mycelium generative hyphae 26- hyphae with thickened axes 27- plectenchymatic tissue 28- distribution of the nuclei in the polyspermic culture BAFC N°599.

KEY FOR THE CULTURAL IDENTIFICATION OF THE *HYMENOCHAETE* SPECIES STUDIED.

2*a*, 6, 7, 11, 32, 37, 39, 45, 50, 54. . . .	*H. cinnamomea*
2*a*, 6, 7, (22), 32, 37, 39, 47, 50, 54, 64.	*H. leonina*
2*a*, 6, 8, 28*d*, 32, 37, 39, 47, 50, 54 . . .	*H. pinnatifida*
2*a*, 6, 11, 22, 32, 37, 39, 47, 54, 64 . . .	*H. cervina*

2*a*, 6, 11, 32, 37, 39, 43, 50, 54. . . . . *H. sallei*
2*a*, 6, 11, 32, 37, 39, 47, 54, 64. . . . . *H. luteo-badia*

DISCUSSION

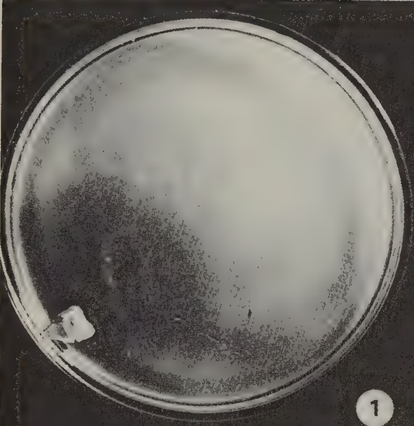
From the results obtained in the present study, and from those of Kühner (1950), Nobles (1948, 1958, 1965), Boidin (1958), Stalpers (1978), Léger *et al.* (1983) and Boidin *et al.* (1984) it appears that the species of the genus *Hymenochaete* Lév. studied in culture present evolved characters viz: the presence of laccases and the absence of clamp connections on hyphae. They also share the characteristic of usually forming a plectenchymatic tissue, and not producing asexual reproductive structures, an exception being *H. rubiginosa* (Boidin, *op. cit.*). Macroscopically they present a common pattern from moderate to slow growth; a mycelial layer that turns from ochre to brown; and a variable texture. In all the cases studied there occurred a change in the culture medium to brown. Characteristic structure of the basidiocarps, like setae or dendrophyses have only been observed in *H. cruenta* (Boidin, *op. cit.*) and *H. pinnatifida*, respectively.

In their general macroscopics features they exhibit a similarity with cultures of other Hymenochaetaceae so far studied, particulary species of the genus *Phellinus*. It would thus appear that the culture patterns of the members of this family support its position as a homogeneous taxon.

ACKNOWLEDGEMENTS

We thank Dr. J.E. Wright for supervising this work, and for his constant support and advice. We also wish to express our gratitude to Dr. M. Rajchenberg and to the F.C.E. y N. (UBA) Mycology Laboratory members for their invaluable cooperation. Special thanks are due to Dr. H.H. Burdsall; Dr. P.L. Lanquetin and Dr. J.C. Léger for critically reading the type script.

Aspect of six week old cultures of: Fig. 1- *H. cervina* Fig. 7- *H. cinnamomea* Fig. 12- *H. leonina* Fig. 16 *H. luteo-badia* Fig. 20- *H. pinnatifida* Fig. 24- *H. sallei*.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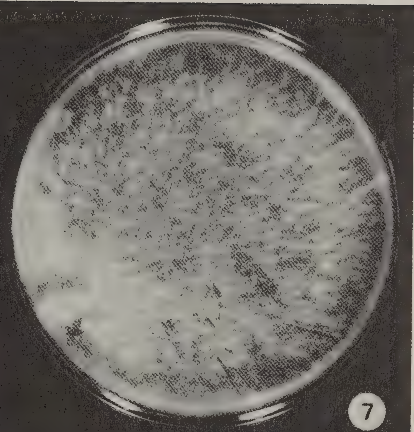
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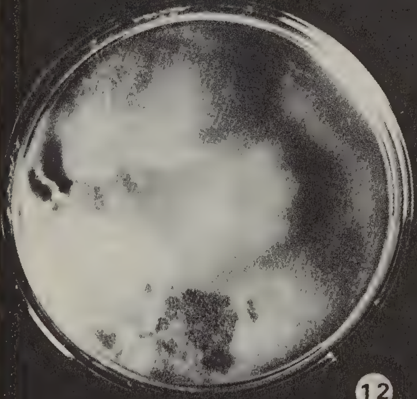
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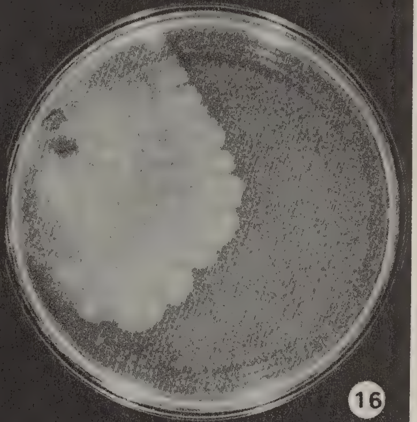
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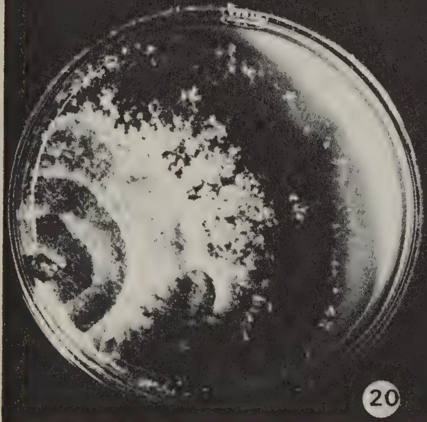
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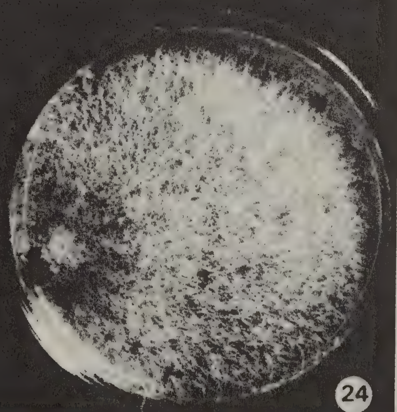
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Notes on the lichen genus *Everniastrum* (Parmeliaceae)

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Summary

The differentiation between the genera *Cetrariastrum* and *Everniastrum* is reevaluated, and the genus *Everniastrum* reinstated and validated. Twentyseven species are recognized in *Everniastrum*, of which 23 are recombined and 4 described as new: *E. arvidssonii* and *E. latilobum* from Ecuador, *E. subplanum* from Mexico and *E. subvexans* from Guatemala. Distribution patterns in the New World are examined, showing that Mexico and the Central Andes in Ecuador and Peru are the centers of diversity.

1. The separation of *Everniastrum* from *Cetrariastrum*

After Culberson & Culberson (1981) argued against the separation of *Cetrariastrum* from *Everniastrum*, as proposed by Sipman (1980), over 200 additional specimens of both genera were examined by the author. They originated mainly from Ecuador [GB] and the private herbarium of A. Aptroot, Utrecht], but also from Colombia [B], Nepal [B] and Venezuela [MERF, US]. Examination of this material made clear that the following characters can be used to distinguish *Cetrariastrum* from *Everniastrum*:

1. In *Cetrariastrum* the branching pattern of the thallus lobes is irregular. This is in contrast with *Everniastrum*, where all species show a very regular dichotomy in branching pattern of the thallus lobes, unless lobe development is suppressed by isidial or soredial production, as in *E. fragile*. This regular dichotomy of *Everniastrum* means that the lobes divide at regular intervals into two equal secondary lobes, all in the same plane. In *Cetrariastrum* the intervals between the divisions are variable, and usually one of the secondary lobes dominates over the other. Moreover the lobes tend to follow different planes and long unbranched terminal lobes are frequent, giving the plants a more bushy appearence.

The difference is clearly illustrated in Sipman 1980, fig. 3a vs. 3c.
2. The lower cortex does not form a sinus under the apothecium, which consequently seems to be placed on a solid stalk (the character illustrated in Sipman 1980, fig. 1B). No such apothecia, or transitional forms, have been found among representatives of the genus *Everniastrum*, all of which show clearly "hollow apothecium-stalks" (Sipman 1980, fig. 1A). In contrast to fig. 1B (l.c.) the discs of *Cetrariastrum* may be concave, although generally in a lesser degree than those of *Everniastrum*.
3. The asci are smaller, 25-36 x 11-14 µm. In *Everniastrum* the mean size is ca. 50 x 23 µm. The smallest asci show an overlap with those of *Cetrariastrum* in length, 30-40 µm, but they are wider, 15-17 µm. They are of the type illustrated in Sipman (1980, fig. 2A), with a strongly compressed base. Asci with a similar compressed base in *Cetrariastrum* measure about 25 µm in length. The large ocular chamber in the dome of the asci, illustrated in Sipman (1980, fig. 2C) is less useful as a character, because it is not clearly developed in all specimens.
4. The hypothecium, i.e. the layer between the base of the asci and the lower delimitation of the pachydermatic stratum below the hymenium, is thicker. In *Cetrariastrum* the hypothecium is thicker than the ascus length, usually about twice as thick, whereas in *Everniastrum* it is about equal. Correlated with the hymenium, the hypothecium in *Cetrariastrum* is thicker than the hymenium, in *Everniastrum* thinner. The absolute figures for the size of the hypothecium, however, show an overlap between both genera.

The other differences cited in Sipman (1980): the longer marginal rhizines, presence of perpendicular branchlets on them, absence of identifiable secondary products apart from protolichesterinic acid s.l. and atranorin, and the small size and thick wall of the spores, are found occasionally in *Everniastrum* as well, as indicated by Culberson & Culberson (1981).

No differences between *Cetrariastrum* and *Everniastrum* could be found in pycnoconidium type. In both genera (*E. angolense* excepted) this appears to be the bifusiform type, cf. Krog (1982). In contrast the pycnoconidia of *Concamerella pachyderma* are different and belong to the rod-shaped type (Krog 1982), as indicated by Culberson & Culberson (1981).

The expression of characters 1 and 2 in *Everniastrum* seems to link this genus with *Hypotrachyna*, whereas *Cetrariastrum* is in this respect of unclear affinity. Perhaps it is related to *Parmotrema*. Therefore both groups should be kept separate at the generic level.

Cetrariastrum, so delimitated, comprises three species: *C. andense*, *C. dubitans* and *C. ecuadoriense*. Descriptions of these three species are given in Sipman (1980).

In addition to the distributional data in Sipman (1980) *C. dubitans* is also known from Costa Rica and Ecuador: Costa Rica, San José-Cartago border: Cerro Buenavista, ca. 10 km NW of the La Georgina restaurant en route to San José, paramo vegetation ca. 2.6 km S of the Interamerican Highway, on bark of *Arctostaphylos arbutoides*, elev. 3490 m, 4 Jan. 1974, F. Almeda 2422 [DUKE]. Ecuador, Pichincha: Quito, Rucu Pichincha, cushion paramo, elev. 4500 m, 18 July 1982, A. Aptroot & R. Hensen 11140 [hb. Aptroot]; Cotopaxi: Volcán Cotopaxi, northern slopes, páramo, elev. 4000 m, 12 June 1983, A. & L. Arvidsson 2756 pr.p. [GB].

All other species referred to this genus by Culberson & Culberson (1981) belong to the genus *Everniastrum.*

2. Validation of the generic name *Everniastrum*

After Hale (1976) proposed the name *Everniastrum*, Culberson & Culberson (1981) argued that it was not validly published in the absence of a reference to a Latin diagnosis. Two years later Sérusiaux (1983) presented an ample discussion of the nomenclatural problems involved. He applied expressly Art. 48 (ICBN) to demonstrate that *Everniastrum* should not be treated as a synonym of *Xanthoparmelia*, as is its supposed synonym *Parmelia* sect. *Everniiformes* Hue. Of this section the only species presented in the original description (Hue 1898), *Parmelia camtschadalis* Ach., has been proved to belong to *Xanthoparmelia*, and in accordance with Art. 10 (ICBN) the section is a synonym of *Xanthoparmelia*. From *Everniastrum*, however, *Parmelia camtschadalis* is explicitly excluded by Hale in its original description (1976: 347). Therefore Sérusiaux concluded that the name *Everniastrum* is an invalidly published name for a new genus with *Parmelia cirhhata* Fr. as its type. Consequently *Everniastrum* is to be validated with a Latin description.

Everniastrum Hale ex Sipman, **gen.nov.**

Type species: *Everniastrum cirrhatum* (Fr.) Hale ex Sipman, **comb.nov.**
Basionym: *Parmelia cirrhata* E. Fries, Syst. Orb. Veg. 1: 283. 1825
Diagnosis:

Thallus foliosus, 5-10(-30) cm diametro, lobulis angustis, (0.5-)1-2(-4) mm latis, dichotomiter ramosis, facie superiore convexa vel plana, grisea vel fusca, nonnumquam fossulata vel maculata, facie inferiore concava, fusca vel nigra, in parte apicali pallidiore, laeve vel rhizinosa, margine vulgo rhizinis marginalibus 1-3(-6) mm longis fuscis ciliato. Rhizinae simplices vel subdichotomiter ramosae, nonnumquam ramulis perpendicularibus provisae, algis typo "Trebouxia".

Apothecia (1-)3-8(-17) mm diametro, disco rufo, margine griseo nonnumquam maculato vel striato in parte inferiore, pedunculo cavo, cavitate a cortice inferiore thalli obtecto. Hymenium (32-)40-60(-90) µm crassum, hypothecio (20-)30-50(-70) µm crasso infra pachydermatico. Asci late elongati, typo "Parmelia", dimensione (30-)40-60(-75) x (15-)20-25(-35) µm, frequenter basi compresso. Sporae unicellulares ellipticae incolores octonae, dimensione (7-)10-16(-28) x (4-)6-7(-11) µm, maiores nonnumquam reniformes vel/et irregulariter transverse 1-3-septatae. Pycnidia immersa 0.1-0.2 mm diametro, conidiis dimensione 4-7(-8) x <0.7 µm, bifusiformibus (in *E. angolense* 10-13 (-21) µm longis bacilliformibus).

Description:

Thallus foliose, 5-10(-30) cm in diameter, composed of narrow, (0.5-)1-2 (-4) mm wide, regularly dichotomously branching lobes; upper surface usually convex, grey, sometimes with a brown tinge, often bordered by a black line due to an extension of the under-cortex, sometimes grooved or maculate, with a pored epicortex, bare or provided with isidia or soralia; lower surface concave, brown to black, at the tips paler, bare or rhizinate, often with irregular transverse ridges; lobe margins usually ciliate by conspicuous marginal rhizines of ca. 1-3(-6) mm length; rhizines simple or more or less dichotomously branching, occasionally with perpendicular branchlets; upper cortex 20-30 µm thick, without algae-containing chambers, of pachydermatic paraplectenchyma; lower cortex 14-18 µm thick, likewise of pachydermatic paraplectenchyma; algal cells of "Trebouxia"-type, roundish, with thick walls, ca. 5-9 µm in diameter.

Apothecia more or less cup-shaped, (1-)3-8(-17) mm wide, with a brown disc and grey margin. Margin often maculate and wrinkled beneath. Apothecia raised on a short stalk, this stalk hollow by a sinus of the lower cortex, which approaches the hypothecium closely. Hymenium (32-)40-60(-90) µm high. Hypothecium (20-)30-50(-70) µm thick, its lower side composed of pachydermatic paraplectenchyma, forming a cupular excipulum. Asci broadly elongate, (30-)40-60(-75) x (15-)20-25(-35) µm, often with compressed base. Spores unicellular, elliptic, colourless, 8 per ascus, (7-)10-16(-28) x (4-)6-7(-11) µm, the larger ones often slightly reniform and sometimes with 1-3 irregularly distributed transverse septa.

Pycnidia immersed, with a black ostiole, in cross section often ± triangular, 0.1-0.2 mm wide. Pycnoconidia 4-7(-8) x <0.7 µm, of the bifusiform type (Krog 1982) (in *E. angolense* bacillar and up to 13(-21) µm long).

The genus *Everniastrum* belongs in the *Parmeliaceae* because of its foliose thallus, lecanorine apothecia with cupular exciple, and asci of

Parmelia-type.

3. Annotated synopsis of the species of *Everniastrum*

After the validation of the generic name *Everniastrum* all combinations in the genus have to be validated, too, in accordance with Art. 43 (ICBN). This is done in the following list. It is based principally on Culberson & Culberson (1981) but includes additions from Sipman (1980), Wei & Jiang (1982) and new observations.

Everniastrum africanum (Hale ex W. Culb. & C. Culb.) Sipman **comb.nov.**
Basionym: *Cetrariastrum africanum* Hale ex W. Culb. & C. Culb., Bryologist 84: 296. 1981
Everniastrum alectorialicum (W. Culb. & C. Culb.) Sipman **comb.nov.**
Basionym: *Cetrariastrum alectorialicum* W. Culb. & C. Culb., Bryologist 84: 297. 1981
Everniastrum americanum (Meyen & Flotow) Hale ex Sipman **comb.nov.**
Basionym: *Evernia americana* Meyen & Flotow, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur.19, Suppl. 1: 211. 1843
Everniastrum angolense (W. Culb. & C. Culb.) Sipman **comb.nov.**
Basionym: *Cetrariastrum angolense*W. Culb. & C. Culb., Bryologist 84: 299. 1981
Everniastrum arsenei (Hale & M. Wirth) Hale ex Sipman **comb.nov.**
Basionym: *Parmelia arsenei* Hale & M. Wirth, Phytologia 22: 40. 1971
Everniastrum billingsii (W. Culb. & C. Culb.) Sipman **comb.nov.**
Basionym: *Cetrariastrum billingsii*W. Culb. & C. Culb., Bryologist 84: 305. 1981
Everniastrum catawbiense (Degel.) Hale ex Sipman **comb.nov.**
Basionym: *Parmelia sorocheila* var. *catawbiensis* Degelius, Ark.f.Bot. 30A (3): 65. 1941

Parmelia curtata Kurok., described by Kurokawa (1979), seems to belong to *E. catawbiense*. The distinguishing character indicated, the presence of protolichesterinic acid, is not acceptable, since this substance occurs in *E. catawabiense* as well.

Everniastrum cirrhatum (E. Fr.) Hale ex Sipman **comb.nov.**
Basionym: *Parmelia cirrhata* E. Fries, Syst. Orb. Veg. l: 283. 1825
Everniastrum columbiense (Zahlbr.) Hale ex Sipman **comb.nov.**
Basionym: *Parmelia columbiensis* Zahlbr., Catal. Lich. Univ. 6: 6l. 1929

Everniastrum fragile Sipman **spec.nov.**
Latin description in Sipman, 1980, Proc. Konkl. Nederl. Akad. Wetensch. C83: 348, under *Everniastrum fragile* (Nom.inval., Art. 43).

Everniastrum fragile is now also known from Peru (dept. Amazonas, prov. Chachapoyas, Straße Chachapoyas - Cajamarca oberhalb Leimebamba, km 417.5, E-exponierter Steilhang im elfin-forest, elev. 2600 m, 6 Sept. 1982, S.R. Gradstein 26c [B]).

Everniastrum halei (W. Culb. & C. Culb.) Sipman **comb.nov.**
Basionym: *Cetrariastrum halei* W. Culb. & C. Culb., Bryologist 84: 301. 1981

Everniastrum limaeforme (Taylor) Hale ex Sipman **comb.nov.**
Basionym: *Parmelia limaeformis* Taylor, Lond. J. Bot. 6: 170. 1847

This species was long known only from the type specimen. The original description mentions the presence of linear, dichotomously branching lobes with acute tips and a concave lower side, the presence of "granules" on the upper surface, and the origin, from Chiloe, southern Chile. The species reappeared in the literature in 1976, when Hale (p. 348) included it in his genus *Everniastrum.* No description was given, but from his key it becomes evident, that an isidiate species lacking salazinic acid and containing protolichesterinic acid was meant. The next treatment was by Culberson & Culberson (1981), who identified three additional specimens from Central America. These specimens are characterized by the presence of isidia and the absence of identifiable secondary products apart from atranorin and protolichesterinic acid s.l.

Examination of the type specimen, preserved in FH, demonstrated that protocetraric acid is present in *E. limaeforme,* as is also stated on an annotation slip added by Hale in 1960. The specimen shows linear, strongly canaliculate lobes with sparse, short, marginal rhizines. The surface is in part densely covered by fine, black-tipped, sometimes ciliate isidia which begin as black granules. Much of the thallus is white-spotted, apparently by abrasion of the isidia. A second plant with the same characteristics, but lacking the white abraded spots, has been collected in Peru, prov. Ancash, elev. ca. 4200 m (leg. C. de Graaf P 17-2 [U]).

The occurrence of this second specimen in Peru poses doubt on the origin of the type specimen. This doubt is strengthened by the fact that recent records of *Everniastrum* species from Chile include only *E . americanum, E. cirrhatum* and *E. sorocheilum*, none of which seems to occur as far south as Chiloe (Culberson & Culberson 1981). Therefore a more northern origin of the type specimen of *E. limaeforme*seems probable, and the locality suggested by its name, Lima, seems more likely. This would be equally in accordance with the known collecting activities of the original collector, Cuming, which also covered Peru according to the Collectors Index (Lanjouw & Stafleu 1954).

The only fruiting specimen reported of *E. limaeforme* (Culberson &

Culberson 1981), from Costa Rica, is recognized here as belonging to *Cetrariastrum dubitans*. That explains why Culberson & Culberson (1981) reported the occurrence of several characteristics of *Cetrariastrum* in *E. limaeforme*.

Two plants from Guatemala, identified by Culberson & Culberson (1981) as *Cetrariastrum limaeforme*, differ considerably in having wide thallus lobes, measuring usually 1.5-2.5 mm in width, and very long and robust marginal rhizines, frequently over 5 mm long. They bear rather scattered, fine isidia which are frequently black-tipped and ciliate. The regular lobe dichotomy places them clearly in the genus *Everniastrum*, and the above-mentioned characters, combined with their chemistry, make clear that they belong to a new species, which is described below as *E. subvexans*.

Everniastrum lipidiferum (Hale & M. Wirth) Hale ex Sipman **comb.nov.**

Basionym: *Parmelia lipidifera* Hale & M. Wirth, Phytologia 22: 37. 1971.

The status of the present species seems unclear (cf. Culberson & Culberson 1981). Perhaps deficient strains of more than one species are involved.

Everniastrum mexicanum (Egan ex W. Culb. & C. Culb.) Sipman **comb. nov.**

Basionym: *Cetrariastrum mexicanum* Egan ex W. Culb. & C. Culb., Bryologist 84: 287. 1981

Everniastrum neocirrhatum (Hale & M. Wirth) Hale ex Sipman **comb.nov.**

Basionym: *Parmelia neocirrhata* Hale & M. Wirth, Phytologia 22: 37. 1971

Everniastrum nepalense (Taylor) Hale ex Sipman **comb.nov.**

Basionym: *Parmelia nepalensis* Taylor, London Journ. Bot. 6: 172. 1847

Everniastrum nigrociliatum (Bouly de Lesd.) Hale ex Sipman **comb.nov.**

Basionym: *Parmelia nigrociliata* Bouly de Lesd., Ann. Cryptog. Exot. 6: 117. 1933

As indicated already by Culberson & Culberson (1981) this species is very variable. In northern Central America wide lobes, long and robust rhizines, and non-perforate apothecia predominate, in South America narrow, strongly convolute lobes, short and slender rhizinae, and perforate apothecia. In the southern parts of Central America both types occur, together with intermediate plants. Therefore a division into two species does not seem appropriate.

Everniastrum peruvianum (Hale ex W. Culb. & C. Culb.) Sipman **comb. nov.**

Basionym: *Cetrariastrum peruvianum* Hale ex W. Culb. & C. Culb., Bryologist 54: 291. 1981

Everniastrum planum Sipman **spec.nov.**

Latin description in Sipman, 1980, Proc. Konkl. Nederl. Akad. Wetensch. C83: 349, under *Everniastrum planum* (Nom.inval., Art.43)

This species is still known only from two localities, the Sierra Nevada de Santa Marta in Colombia and the Cerro de la Muerte in Costa Rica. The population in Costa Rica has been collected several times. The plants are sometimes sparsely sorediate.

Everniastrum pseudonepalense (Hale & M. Wirth) Hale ex Sipman **comb. nov.**

Basionym: *Parmelia pseudonepalense* Hale & M. Wirth, Phytologia 22: 40. 1971

Everniastrum rhizodendroideum (Wei & Jiang) Sipman **comb.nov.**

Basionym: *Cetrariastrum rhizodendroideum* Wei & Jiang, Acta Phytotax. Sin. 20: 496. 1982

This species, characterised by short and densely branched rhizines, was recently described from Tibet. Collections have also been made in Nepal: Khumbu Himal, between Namche Basar (3440 m) and Ghat (2490 m), 9 April 1981, leg. S. Remus & M. Menzel 131, 147 [B]. The latter specimen bears apothecia, and the following additions to the original description are taken from it: Apothecia to 2.6 mm diam., concave. Hymenium ca 65 µm high. Hypothecium ca 40 µm thick. Asci 40 x 22 to 50 x 24 µm. Spores 16-20 x 8-9 µm, elliptic or weakly reniform.

Everniastrum sorocheilum (Vainio) Hale ex Sipman **comb.nov.**

Basionym: *Parmelia sorocheila* Vainio, Hedwigia 38: [123]. 1899

Everniastrum subnepalense (Hale ex W. Culb. & C. Culb.) Sipman **comb. nov.**

Basionym: *Cetrariastrum subnepalense* Hale ex W. Culb. & C. Culb., Bryologist 54: 304. 1981

Everniastrum vexans (Zahlbr. ex W. Culb. & C. Culb.) Hale ex Sipman **comb.nov.**

Basionym: *Cetrariastrum vexans* Zahlbr. ex W. Culb. & C. Culb., Bryologist 84: 294. 1981

A few seemingly transitional forms between *E. vexans*, *E. columbiense* and *E. fragile* have been encountered from Ecuador. Typical *E. vexans* is very distinct from both by the long, rather strongly convolute lobes with rather scattered, fine isidia. However, forms occur in which the lobes are densely covered with isidia, as in Arvidsson 4200 [GB]. In some such plants the isidia are very short, and parts of the thallus could be called pustulate rather than isidiate, as in Arvidsson 2803 [GB]. Similar pustulate areas can be observed in *E. columbiense*. In critical cases the presence of distinct, ciliate isidia has been used to recognize *E. vexans*. Another collection of *E. vexans* from Ecuador, Arvidsson 3438 [GB], has dense, conspicuously coralloid-branched isidia. In this respect it comes close to *E. fragile* but differs in the absence of terminal isidia and the predominance of elongate lobes.

4. Four new species

Everniastrum arvidssonii Sipman **spec.nov. (Fig. 1)**
Type: Ecuador, Azuay, road Cuenca-Loja, southern parts of Páramo de Tinajullas, epiphyte, elev. 3000-3200 m, 9 May 1974, L. Arvidsson 357b [GB].
Latin diagnosis:

Thallus albidus, ca. 6-10 cm diametro. Lobi paulo usque ad forte convoluti, 1-1.5(-2) mm lati, internodiis 2-4 mm longis. Isidia et soredia absentia. Margo crebriore ciliatus a rhizinis marginalibus. Facies inferior rhizinata, omnino atra. Rhizinae marginales 0.5-1(-1.5) mm longae, ramosae, ramulis perpendicularibus praedominantibus, rhizinae inferiores minores. Materiae chimicae atranorinum, acidum protolichesterinicum s.l. et acidum gyrophoricum continens.

Apothecia 2-11 mm lata, omnes perforata. Discus juvenile concavissimus, magniore subplanus. Hymenium 50-60 µm crassum. Hypothecium 40-50 µm crassum. Asci 42 x 18 usque ad 55 x 20 µm. Sporae 10 x 6-7 µm. Pycnoconidia ca. 6 µm longa.

Description:

Thallus whitish, ca. 6-10 cm diam. Lobes slightly to rather strongly convolute, 1-1.5(-2) mm wide, with 2-4 mm long internodes. Isidia and soredia absent. Margins rather densely ciliate by marginal rhizines. Lower surface rhizinate, black throughout. Marginal rhizines 0.5-1(-1.5) mm long, rather densely branched with predominantly perpendicular branchlets, the rhizines on the lower surface less well developed. Chemistry: atranorin, protolichesterinic acid s.l. and gyrophoric acid.

Apothecia 2-11 mm wide, all perforate. Disc in young apothecia strongly concave, in larger apothecia more or less flat. Hymenium 50-60 µm high. Hypothecium 40-50 µm thick. Asci 42 x 18 to 55 x 20 µm. Spores 10 x 6-7 µm. Pycnoconidia ca. 6 µm long.

Everniastrum arvidssonii resembles south american plants of *E. nigrociliatum* in chemistry and in the occurence of perforate apothecia, but differs by its rhizines, which are richly branched and not restricted to the margin.

Everniastrum latilobum Sipman **spec.nov. (Fig. 2)**
Type: Ecuador, Zamora-Chinchipe, road Loja-Zumba, 4 km N of Valladolid, mountain rainforest, epiphyte, elev. 1200 m, 16 July 1983, L. & A. Andersson 4695 [US].

Latin diagnosis:

Thallus albidus, 6 cm diametro excedens. Lobi plani vel paulo convoluti, 3-5 mm lati, internodiis 3-5 mm longis. Facies superior isidiis sparsis crassioribus fuscocapitatis cylindricis instructa. Margo a rhizinis marginalibus ciliatus. Facies inferior nuda vel rhizinis singulis ad marginem instructa, atra, ad apices loborum fusca. Rhizinae ca. 1.5 mm (max. 2 mm) longae, dichotomiter vel irregulariter ramosae. Materia chimica atranorinum et acidum salazinicum continens. Apothecia et pycnidia ignota.

Description:

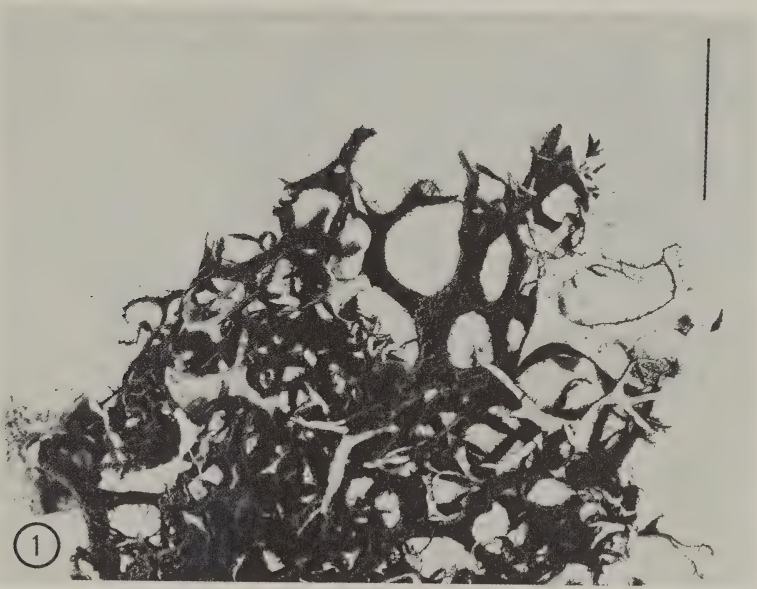
Thallus whitish, over 6 cm diam. Lobes flat or slightly convolute, 3-5 mm wide, with 3-5 mm long internodes. Upper surface with scattered, rather thick, brown-tipped, cylindrical isidia, which may develop into lobules with ciliate margins. Margins ciliate by marginal rhizines. Lower surface bare or with occasional rhizines near the margin, black, but brown near the lobe tips. Rhizines ca. 1.5 mm (max. 2 mm) long, dichotomously or irregularly branched. Chemistry: atranorin and salazinic acid (teste M.E. Hale). Apothecia and pycnidia unknown.

This species, known only from the type, differs significantly from all known *Everniastrum* species in the wide lobes and coarse, cylindrical isidia. Superficially it resembles species of *Hypotrachyna* by the wide, short lobes, but it differs clearly from this genus in the (nearly) exclusively marginal rhizines.

Everniastrum subplanum Sipman **spec.nov. (Fig. 3)**
Type: Mexico, Michoacán, Ciudad Hidalgo, about 1 km from Mirador Atzimbo on road to Puerto Garnacia, 49 km by road W of Ciudad Hidalgo on road to Morelia, conifer forest with *Pinus*, *Abies*, *Buddleia* and *Clethra*, elev. 3100 m, 7 Nov. 1977, R.S. Egan E1-10639 [US].

Latin diagnosis:

Thallus albidus, albo-maculatus, 6 cm diametro excedens. Lobi subplanati vel paulo convoluti, 2.5-5 mm lati, internodiis 4-8 mm longis. Facies superior soraliis pustularibus vel crasso-sorediatis superficialibus vel subterminalibus obtecta. Margo conspicue atro-marginatus, a rhizinis marginalibus ciliatus. Facies inferior nuda, atra, ad apices loborum fusca. Rhizinae crassae, (1-)3-5 mm longae, vulgo simplices. Materia chimica atranorinum et acidum salazinicum continens. Apothecia et pycnidia ignota.



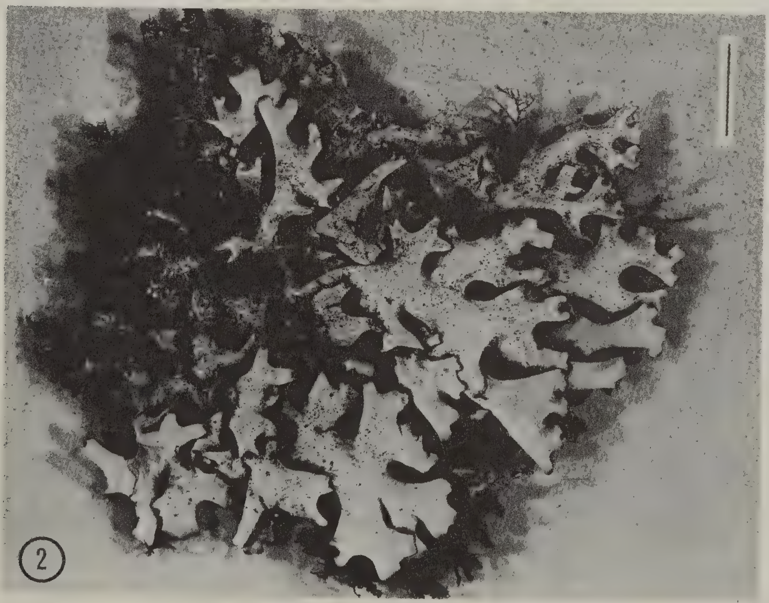


Fig. 1, *Everniastrum arvidssonii*, type; **Fig.** 2, *E. latilobum*, type. Bar indicates 1 cm.

Description:

Thallus whitish, in part white-maculate, over 6 cm diam.. Lobes nearly flat or slighty convolute, 2.5-5 mm wide, with 4-8 mm long internodes. Upper surface with pustular or coarsely sorediate, superficial or subterminal soralia. Margin with a conspicuous black rim, ciliate by marginal rhizines. Lower surface bare, black, brown near the tips. Rhizines coarse, (1-)3-5 mm long, generally simple. Chemistry: atranorin and salazinic acid. Apothecia and pycnidia unknown.

This species resembles *E. planum*, but differs in chemistry and longer lobes.

Everniastrum subvexans Sipman **spec.nov. (Fig. 4)**
Type: Guatemala, Sololá, Volcán Atitlán, south-facing slopes, elev. 1700-3800 m, 11 June 1942, J.A. Steyermark 47463 [US].

Latin diagnosis:

Thallus albidus, albo-maculatus, 4 cm diametro excedens. Lobi plani vel paulo convoluti, (1.2-)1.5-2.0(-2.5) mm lati, internodiis 2-15 mm longis. Facies superior isidiis tenuibus cylindricis nigrocapitatis, nonnumquam ciliatis obtecta. Margo vulgo crasse atro-marginatus, a rhizinis marginalibus ciliatus. Facies inferior nuda, atra, ad apices loborum atrofusca. Rhizinae crassae, ca. 5 mm longae, simplices vel parce dichotomiter ramosae. Materiae chimicae atranorinum et acidum protolochesterinicum s.l. continens. Apothecia et pycnidia ignota.

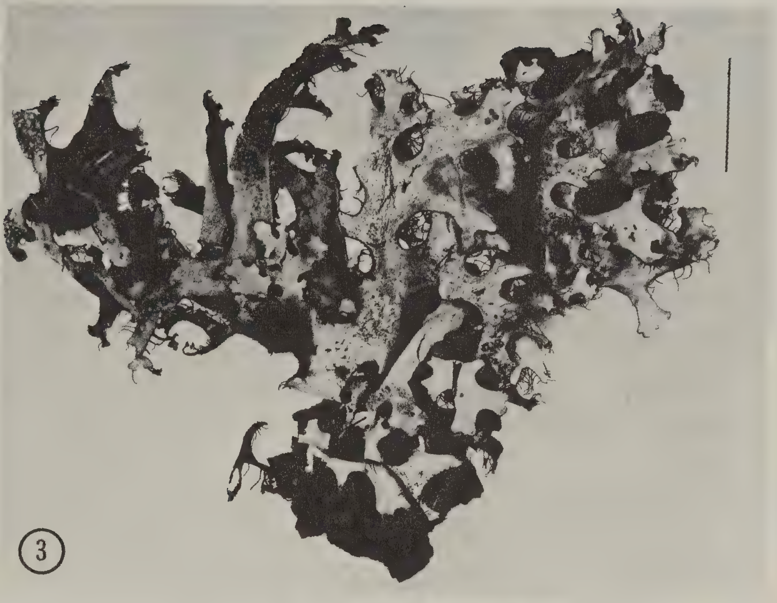
Description:

Thallus whitish, white-maculate, over 4 cm diam.. Lobes flat to slightly convolute, (1.2-)1.5-2.0(-2.5) mm wide, with 2-15 mm long internodes. Upper surface with scattered fine, cylindrical, black-tipped, sometimes ciliate isidia. Margin generally with a strong black rim, ciliate by marginal rhizines. Lower surface bare, black, dark brown near the lobe tips. Rhizines coarse, ca. 5 mm long, unbranched or sparingly dichotomously branched. Chemistry: atranorin and protolichesterinic acid s.l. Apothecia and pycnidia unknown.

Everniastrum subvexans resembles *E. imitatum* in chemistry, but differs in the presence of isidia. The only available specimens had been included in *Cetrariastrum limaeforme* by Culberson & Culberson (1981).

Additional specimen:

Guatemala, San Marcos, upper south-facing slopes of V. Tajumulco, between Las Canojas and top of ridge, 7 mi. from San Sebastián, elev.



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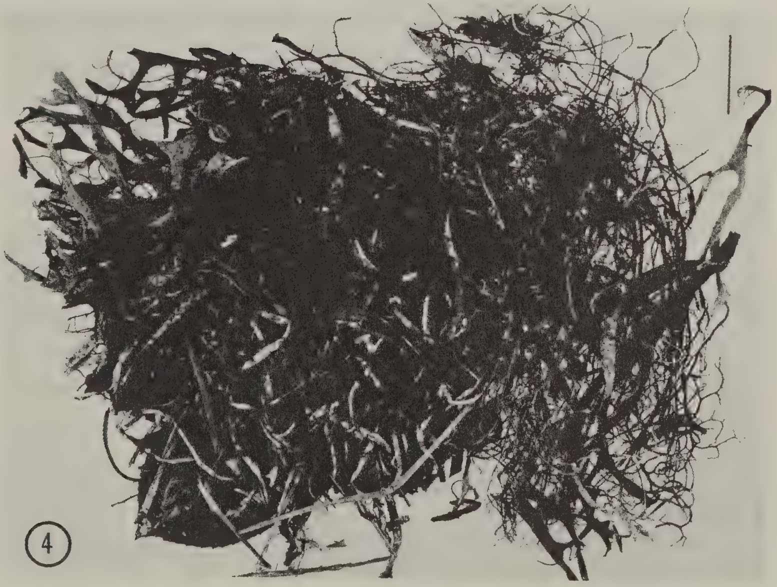

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Fig. 3, *Everniastrum subplanum*, type; **Fig.** 4, *E. subvexans*, type. Bar indicates 1 cm.

Area:	Number of species:	Number of endemics:	Chemical variations:
Mexico	10	3	5
Central America, south of Mexico	8	1	4
Venezuela	8	-	3
Colombia	9	-	3
Ecuador	10	2	3
Peru	10	4	4
Chile	3	1	2
Argentina	2	-	1

Table 1: Variability of *Everniastrum* in the Neotropics. For a selection of areas with comparable size and geographical differentiation the number of species, number of endemics, and number of chemical variations are indicated. For the chemical variability the following seven types were distinguished basing on the main medullary substance: 1. salazinic acid; 2. gyrophoric acid; 3. protocetraric acid; 4. norstictic acid; 5. constictic acid; 6. fumarprotocetraric acid; 7. none of these, only protolichesterinic acid s.l. present.

3300- 3900 m, 16 Febr.1940, J.A. Steyermark s.n. [US, MO-nr. 168285].

5. Note on the geographical variation of *Everniastrum* in the New World

A survey of the variability of the *Everniastrum*-flora in the Neotropics is given in table 1. It is compiled from Sipman (1980), Culberson & Culberson (1981), and new information from the collections studied during the preparation of this article.

The table shows that Central America and the northern and central Andes have species numbers above 3, which means that they exceed any other areas in the world in species number (cf. Culberson & Culberson 1981, fig. 2). Inside this neotropical range the number of species is rather constant. However, the number of endemics and of chemical variations show the presence of two disjunct centers of evolution, Central America and the Central Andes of Ecuador and Peru.

6. Key to the species of *Everniastrum*

1a	Isidia present		2
b	Soredia or pustules present		5
c	Isidia, soredia and pustules absent		9
2a	Medulla P-, K-; thallus lobes over 3 mm wide	*E. subvexans*	
b	Medulla P+orange or red, K- or + yellow-> red; thallus lobes less than 2 mm wide		3
3a	Medulla P+red, K- (protocetraric acid)	*E. limaeforme*	
b	Medulla P+orange, K+yellow->red (salazinic acid)		4
4a	Isidia laminal, often ciliate	*E. vexans*	
b	Isidia terminal or marginal, rarely ciliate	*E. fragile*	
5a	Medulla K+ yellow->red, C- (salazinic acid)		6
b	Medulla K-, C+red (gyrophoric acid)		8
6a	Soredia scattered over the upper surface	*E. columbiense*	
b	Soredia in well-delimited, usually subterminal soralia		7
7a	Thallus lobes over 2.5 mm wide	*E. subplanum*	
b	Thallus lobes less than 2 mm wide	*E. sorocheilum*	
8a	Thallus lobes over 2 mm wide	*E. planum*	
b	Thallus lobes less than 1.5 mm wide	*E. catawbiense*	
9a	Rhizinae short and bundled in tufts; Peru and Chile		10
b	Rhizines single, of varying length, marginal and/or laminal; widespread		11
10a	Medulla K+yellow->red (salazinic acid)	*E. billingsii*	
b	Medulla K- (protolichesterinic acid only)	*E. americanum*	

11a Medulla K+yellow->red (salazinic, occasionally constictic acid) 12
b Medulla K- (salazinic or constictic acid absent) 20

12a Rhizines (nearly) only marginal 13
b Rhizines mostly laminal 16

13a Rhizines richly branched, short; Asia *E. rhizodendroideum*
b Rhizines unbranched or only a few times branched 14

14a Constictic acid present; Peru *E. peruvianum*
b Salazinic and norstictic acid present; Mexico 15
c Salazinic acid only; widespread *E. cirrhatum*

15a Rhizines only marginal; protocetraric acid absent *E. neocirhhatum*
b A few laminal rhizines usually present; protocetraric acid sometimes present *E. pseudonepalense*

16a Protolichesterinic acid absent; conidia rodshaped; Africa *E. angolense*
b Protolichesterinic acid present; conidia bifusiform (as far as known) 17

17a From America; norstictic or lobaric acid present 18
b From Asia; norstictic and lobaric acid absent 19

18a Norstictic acid present; Mexico *E. pseudonepalense*
b Lobaric acid present; Bolivia *E. halei*

19a Alectorialic acid present *E. alectorialicum*
b Alectorialic acid absent *E. nepalense*

20a Rhizines only marginal 21
b Rhizines mainly laminal 23

21a Medulla P+ red (protocetraric acid) *E. mexicanum*
b Medulla P- (gyrophoric acid or only protolichesterinic acid) 22

22a Medulla C+ or KC+ red (gyrophoric acid) *E. nigrociliatum*
b Medulla C-, KC- (protolichesterinic acid only) *E. lipidiferum*

23a Medulla P+ red, C- or C+ red; apothecia not perforate 24
b Medulla P-, C+ red (gyrophoric acid); apothecia perforate *E. arvidssonii*

24a Alectoronic and echinocarpic acid present; Africa
E . africanum
b Protocetraric or fumarprotocetaric acid present; neotropical 25

25a Protocetraric acid present *E. arsenei*
b Fumarprotocetraric acid present *E. subnepalense*

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THE INFLUENCE OF MICROHABITAT ON DIVERSITY, DISTRIBUTION AND ABUNDANCE OF CORTICOLOUS LICHENS IN ZION NATIONAL PARK, UTAH AND NAVAJO NATIONAL MONUMENT, ARIZONA

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SUMMARY

Three important effects of decreasing aridity on the distribution of corticolous lichens in Navajo National Monument and Zion National Park have been observed. First, in dry habitats lichens were predominantly restricted to north exposures of host trees while in more mesic habitats they occurred on all exposures. Second, species diversity increased in more mesic habitats. And third, total lichen cover increased in wetter environments.

INTRODUCTION

Differential distribution patterns of corticolous lichens have been the subject of several studies. Barkman (1958) summarized much of the early work done and prepared a comprehensive record of the ecology and phytosociology of cryptogamic epiphytes. He discussed the individual and collective influences of various environmental factors on the distribution of corticolous lichens and bryophytes.

Substantial data also exist concerning substrate specificity and distribution patterns of corticolous lichens on phorophytes (Hale 1955, Brodo 1961, Adams and Risser 1971). The influence of various substrate factors, including pH, water-holding capacity, stability and exposure on the distribution of corticolous lichens, have been evaluated. Vertical and horizontal distribution patterns of corticolous lichens have also been examined (Hale 1965, Hinds 1970, Harris 1971, Peard 1983). The influence of microclimate on epiphyte distribution has also been studied (Hoffman and Kazmierski 1969, Pearson 1969, Peard 1983). However, data documenting the direct influence of microhabitat on horizontal distribution patterns, abundance and species diversity for corticolous lichens are rare.

We have been involved in studies of the lichen floras of Zion National Park, Utah and Navajo National Monument, Arizona for several years. A checklist of lichen species for the Navajo area has been published (Nebeker and St. Clair 1984) as well as two papers dealing with lichen community structure (Rushforth et al. 1982, Rushforth et al. 1984). While conducting these studies, we observed several distinct differences between corticolous lichens at the various study sites. In particular, we observed differences in species diversity, distribution patterns and abundance between north, south, east and west exposures on phorophytes. This paper documents and attempts to explain these differences.

SITE DESCRIPTIONS

Zion National Park is located in southern Utah approximately 55 km northeast of St. George, Washington County. Navajo National Monument is located in the northeastern part of Arizona near Kayenta in Navajo County. The field sites of our study were established in Zion Canyon, Zion National Park, and Betatakin Canyon, Navajo National Monument. Both are formed from massive cliffs of the Navajo Sandstone Formation. Both canyons are deep, often narrow gorges with prominent streams. The deep nature of these canyons creates microhabitats substantially different from those of the surrounding desert. In particular, temperature, wind, soil moisture, humidity and insolation are all substantially moderated. The entire bottom of Betatakin Canyon is rather mesic, with conditions becoming drier upslope and down canyon. Zion Canyon becomes more mesic toward the head of the canyon. Both the vascular and nonvascular floras reflect this transition.

The mouth of both Zion and Betatakin Canyons, as well as the slickrock mesa above Betatakin Canyon are dominated by *Pinus edulis* Engelm. and *Juniperus osteosperma* (J. Torr.) Little. The head of Zion Canyon is dominated by *Acer grandidentatum* Nutt., *Populus fremontii* S. Wats., and *Fraxinus anomala* J. Torr. while mid-Zion Canyon is dominated by *Quercus turbinella* Greene and *Quercus gambelii* Nutt. The head of Betatakin Canyon is dominated by *Populus tremuloides* Michx., *Pseudotsuga menziesii* Franco and *Quercus gambelii*.

METHODS

Individual trees for determining the occurrence and distribution of corticolous lichens were selected using the quarter method (Phillips 1959). This method is a proven plotless sampling technique in which points along a line transect are identified. The area around each point is divided into four quadrants and the nearest tree in each quadrant is sampled. Frequency and percent cover of corticolous lichens on each tree were determined using a 2 x 100 cm quadrat with 10 equal subquadrats (Rushforth et al. 1982). In order to determine the effect of aspect on species distribution and abundance, north, south, east, and west exposures on individual trees were sampled separately and consistently. The sampling quadrat was placed on the north, south, east and west sides of each phorophyte 1 m above the ground. Percent cover of each lichen species was estimated visually. Cover values were averaged by aspect, phorophyte species and site location.

RESULTS AND DISCUSSION

Strong trends in the distribution of lichen taxa according to exposure on the bark of various phorophytes were observed. In drier habitats such as the mouth of Zion Canyon and the mesa above Betatakin Canyon, lichens on host trees were generally restricted to northern exposures (Tables 1-2). Conversely, corticolous lichens in the more mesic locations, such as the bottom of Betatakin Canyon and the head of Zion Canyon, were more broadly distributed according to aspect (Tables 1-2).

The restriction of lichen taxa to the north exposure in drier sites varied somewhat according to phorophyte species. For example, in the dry habitats at both Zion and Navajo, *Pinus edulis* consistently had lichen taxa occurring on exposures other than north, although the northern exposure consistently supported the greatest total lichen cover. Distribution of lichens on *Pinus monophylla* J. Torr. & Frem. at the mouth of Zion Canyon showed a similar trend.

Total cover according to host species also showed evident trends. For instance, *Pseudotsuga menziesii* in Betatakin Canyon consistently had the highest total lichen cover at that site as did *Acer grandidentatum* at Zion Canyon (Tables 3-4). *Juniperus osteosperma* consistently had the lowest total cover at all sites.

Lichen species diversity according to both aspect and host was consistently lower in the drier localities. In general, host trees at dry sites averaged from 2 to 4 lichen taxa whereas host trees at mesic localities averaged from 7 to 14 taxa (Table 3).

Several lichen species were broadly distributed according to both moisture and host. For example, Xanthoria fallax (Hepp) Arn. at Betatakin Canyon occurred on all possible host species. Likewise, Physcia orbicularis (Neck.) Poetsch and Physica stellaris (L). Nyl. at Zion Canyon were found on 7 out of 8 possible host species (Tables 3-4).

Moisture and host species appear to be the major factors influencing horizontal distribution of corticolous lichens in our study areas. Both of these factors are strongly influenced by canyon morphology which creates distinct microhabitats of very different moisture regimes across short distances which in turn influences the vascular flora. Such microhabitats are influenced by several environmental factors including wind, insolation, temperature, soil moisture and relative humidity, all of which are substantially moderated in areas of steep canyon walls. The canyons contain a richer and denser vascular plant flora which in turn provides a wider range of potential host species. In addition, the presence of these trees further increases relative humidity and soil moisture and decreases temperature. In combination, these factors create a microhabitat which influences the development of the lichen flora. Consequently, the more temperate microhabitat of the mesic sites results in an increase in diversity and abundance of lichens.

It has been observed that epiphytes are more abundant on the northern exposures of the trunks of host species in northern latitudes (Barkman 1958). This phenomenon apparently is a function of both reduced insolation and lowered mean temperature and temperature extremes which result in increased moisture availability (Barkman 1958, Peard 1983). Such phenomena are intensified in dry environments such as those at the mouth of Zion Canyon and the mesa above Betatakin Canyon. However, in the more mesic habitats such as the heads of Betatakin and Zion Canyons, the influence of aspect on lichen species distribution is greatly reduced.

Table 1. Average percent cover of lichen species by substrate and aspect at Betatakin Canyon, Navajo National Monument.

Species	Exposure North	 South	 East	 West
Juniperus osteosperma (mesa above canyon)				
Caloplaca arizonica	.02	---	---	---
Physcia stellaris	.01	---	---	---
Xanthoria fallax	.01	---	---	---
Total lichen cover	.04	---	---	---
Pinus edulis (mesa above canyon)				
Parmelia subolivacea	.13	.01	.03	.01
Physcia stellaris	.01	---	---	---
Usnea hirta	.05	---	.01	---
Xanthoria fallax	.01	---	---	---
Total lichen cover	.20	.01	.04	.01
Populus tremuloides (botton of canyon)				
Candelariella deflexa	.02	.01	.01	.07
Lecanora hageni	.01	---	.04	---
Physconia pulverulenta	---	---	.01	---
Xanthoria fallax	.01	---	.01	---
Total lichen cover	.04	.01	.07	.07
Pseudotsuga menziesii (bottom of canyon)				
Buellia punctata	.03	.05	.04	.01
Caloplaca arizonica	---	---	.03	.01
Candelariella deflexa	---	---	.01	---
Cladonia pyxidata	---	---	.01	.02
Heterodermia speciosa	.01	.01	.03	.01
Lecanora chlarotera	---	---	.01	.02
Lecanora hageni	.01	.01	---	.01
Lecidella euphorea	---	---	---	.01
Pachyospora mutabilis	----	.01	.03	.02
Parmelia subolivacea	.03	.01	---	.02
Physcia dubia	.10	---	---	.03
Physconia grisea	---	---	.03	.06
Physconia pulverulenta	.01	.01	.02	.01
Xanthoria fallax	.02	.01	---	.01
Total lichen cover	.21	.11	.21	.24

Table 1 (continued)

Species	Exposure North	South	East	West
Quercus gambelii (bottom of canyon)				
Caloplaca arizonica	.02	.02	.01	.01
Xanthoria fallax	.01	---	.01	.01
Total lichen cover	.03	.02	.02	.02

Table 2. Average percent cover of lichen species by substrate and aspect at Zion Canyon, Zion National Park.

Species	Exposure North	South	East	West
Juniperus osteosperma (mouth of canyon)				
Physcia orbicularis	.03	---	---	---
Physcia stellaris	.03	---	---	---
Total lichen cover	.06	---	---	---
Pinus edulis (mouth of canyon)				
Parmelia subolivacea	.02	---	---	.01
Physcia orbicularis	.01	---	---	.01
Physcia stellaris	.01	---	---	---
Total lichen cover	.04	---	---	.02
Pinus monophylla (mouth of canyon)				
Parmelia subolivacea	.40	---	---	.20
Physcia stellaris	.10	.01	.10	---
Total lichen cover	.50	.01	.10	.20
Quercus turbinella (mid-canyon)				
Candelariella deflexa	---	---	.02	---
Physcia stellaris	---	---	.02	.01
Physcia orbicularis	.06	---	---	.08
Total lichen cover	.06	---	.04	.09

Table 2 (continued)

Species	Exposure			
	North	South	East	West
Quercus gambelii (mid-canyon)				
Caloplaca arizonica	.01	---	---	---
Candelariella deflexa	.02	---	---	.01
Collema furfuraceum	.11	---	---	.01
Parmelia subolivacea	.02	---	---	.01
Physcia orbicularis	.40	.02	.01	.10
Physcia stellaris	1.30	.10	.08	.54
Xanthoria fallax	1.20	.42	.60	.90
Total lichen cover	3.06	.54	.69	1.57
Acer grandidentatum (head of canyon)				
Candelariella deflexa	.76	1.20	.88	1.10
Collema furfuraceum	3.60	.90	3.70	2.00
Parmelia subolivacea	.78	6.32	1.40	4.80
Physcia orbicularis	8.80	11.80	3.62	8.40
Physconia pulverulenta	44.00	26.10	33.80	24.30
Physcia subtilis	2.00	---	.70	.06
Xanthoria fallax	2.40	6.00	4.30	5.80
Total lichen cover	62.34	52.32	48.40	46.46
Fraxinus anomala (head of canyon)				
Candelariella deflexa	.20	.02	.04	.03
Physcia orbicularis	.07	---	---	---
Physcia stellaris	.40	.01	.20	.02
Xanthoria fallax	.07	.01	.02	.01
Total lichen cover	.74	.04	.26	.06
Populus fremontii (head of canyon)				
Candelariella deflexa	2.50	.03	.60	.44
Collema furfuraceum	.02	---	---	---
Heterodermia speciosa	.10	---	---	.03
Lecanora hageni	.02	---	---	---
Physcia orbicularis	3.70	---	.19	.78
Physcia subtilis	.30	---	---	---
Physcia stellaris	.40	---	.01	.05
Rinodina pyrina	.70	---	---	---
Xanthoria fallax	.34	---	.07	.06
Xanthoria polycarpa	.55	---	.01	---
Total lichen cover	8.63	.03	.88	1.36

Table 3. Average cover of lichen species by substrate and aspect at Betatakin Canyon, Navajo National Monument.

	Tree species*				
Lichen species	Juos	Pied	Potr	Psme	Quga
Buellia punctata	---	---	---	.03	---
Caloplaca arizonica	.01	---	---	.01	.02
Candelariella deflexa	---	---	.02	.01	---
Cladonia pyxidata	---	---	---	.01	---
Heterodermia speciosa	---	---	---	.01	---
Lecanora chlarotera	---	---	---	.01	---
Lecanora hageni	---	---	.01	.01	---
Lecidella euphorea	---	---	---	.01	---
Pachyospora mutabilis	---	---	---	.01	---
Parmelia subolivacea	---	.05	---	.02	---
Physcia dubia	---	---	---	.03	---
Physcia stellaris	.01	.01	---	---	---
Physconia grisea	---	---	---	.02	---
Physconia pulverulenta	---	---	.01	.01	---
Usnea hirta	---	.01	---	---	---
Xanthoria fallax	.01	.01	.01	.01	.01
Total lichen cover	.02	.08	.05	.20	.03

*Tree species = Juos (*Juniperus osteosperma*)
Pied (*Pinus edulis*)
Potr (*Populus tremuloides*)
Psme (*Pseudotsuga menziesii*)
Quga (*Quercus gambelii*)

Table 4. Average cover of lichen species by substrate and aspect at Zion Canyon, Zion National Park.

	Tree species*							
Lichen species	Juos	Pied	Pimo	Quga	Qutu	Acgr	Fran	Pofr
Caloplaca arizonica	---	---	---	.01	---	---	---	---
Candelariella deflexa	---	---	---	.01	.01	.99	.07	.90
Collema furfuraceum	---	---	---	.03	---	2.60	---	.01
Heterodermia speciosa	---	---	---	---	---	---	---	.03
Lecanora hageni	---	---	---	---	---	---	---	.01
Parmelia subolivacea	---	.01	.15	.01	---	3.33	---	---
Physcia orbicularis	.01	.01	---	.13	.04	8.20	.02	1.20
Physcia stellaris	.01	.01	.05	.50	.01	---	.16	.11
Physcia subtilis	---	---	---	---	---	.69	---	.08
Physconia pulverulenta	---	---	---	---	---	32.10	---	---
Rinodina pyrina	---	---	---	---	---	---	---	.18
Xanthoria fallax	---	---	---	.78	---	4.60	.03	.12
Xanthoria polycarpa	---	---	---	---	---	---	---	.14
Total lichen cover	.02	.03	.20	1.47	.06	52.51	.28	2.78

*Tree species = Juos (*Juniperus osteosperma*)
Pied (*Pinus edulis*)
Pimo (*Pinus monophylla*)
Quga (*Quercus gambelii*)
Qutu (*Quercus turbinella*)
Acgr (*Acer grandidentatum*)
Fran (*Fraxinus anomala*)
Pofr (*Populus fremontii*)

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MARINE FUNGI FROM SEYCHELLES V. BIATRIOSPORA MARINA GEN. ET SP. NOV. FROM MANGROVE WOOD

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During a recent investigation of the higher marine fungi of the Seychelles, an unidentified fungus was collected from mangrove wood. A new genus *Biatriospora* is described to accommodate this fungus, which is characterised by having black ostiolate ascocarps, bitunicate asci with an apical apparatus and brown ascospores with polar longitudinal septa and refractive end chambers. The type species *Biatriospora marina* sp. nov. was collected from Anse Boileau mangrove stand, Seychelles, in January 1984. The fungus has also been collected from the coast of Maharashtra, India and Serasa mangrove stand in Brunei.

BIATRIOSPORA gen. nov.

Ascocarpi solitarii vel gregarii, subglobosi vel pyriformati, in ligno immersi, ostiolati, periphysati, papillati, carbonacei, nigri. *Pseudoparaphyses* numerosi, simplices, angusti, ramificantes, in matrice gelatinosa inclusi. *Asci* octospori cylindrici, pedunculati, bitunicati, pachydermi, cum apparatu apicali, in hymenio ad basim ascocarporum orientes. *Ascosporae* fusiformatae, atrae-brunnae, ad polum utrumque septatae, in medio non-septatae, cum appendicibus vel atriis apicalibus, globosis, refractis. Typus *Biatriospora marina* Hyde et Borse. sp. nov. *Biatrospora: bi* - two, *atrim* = chamber, *spora* = spore, in reference to the refractive hyaline end chamber at each end of the spore.

Ascocarps solitary or gregarious, large, subglobose to pyriform, immersed in the substrate, ostiolate, periphysate, papillate,carbonaceous, black. *Pseudoparaphyses* numerous, simple, thin, branched, hyaline embedded in a gelatinous matrix. *Asci* eight-spored, cylindrical, pedunculate, bitunicate, thick-walled, with an apical apparatus, developing in the hymenium at the base of the ascocarp. *Ascospores* fusiform, dark brown, septate towards each end, non-septate in the centre, with apical globose refractive chambers or appendages. Type species *Biatriospara marina* Hyde and Borse sp. nov.

BIATRIOSPORA MARINA Hyde et Borse. sp. nov. (Figs 1-8)

Ascocarpi 650-860µm longi x 350-510 µm lati, horizontales iocentes in ligno immersi, subglobosi, vel pyriformati, solitarii vel gregarii, nigri, carbonacei, ostiolati et papillati. *Papillae* 150-225 µm longi x 60-75 µm lati, cum periphysibus plenae. *Pseudoparaphyses* 0.6-1.7 µm lati numerosi, simplices, ramificantes, angusti, hyalini, in matrice gelatinosa inclusi. *Asci* 175-400 µm longi x 22-40 µm lati, octospori, cylindrici, longi pedunculati, pachydermi, bitunicati, cum apparatu apicali, hymenio ad basim ascocarporum orientes. *Ascosporae* 55-82 x 16-25 µm, uniseriatae, vel biseriatae, fusiformatae, ad polum utrumque 2-4 septatae, in medio non septatae, sine constrictione ad septum, hyalinae adulescentes, brunneae vel atrae-brunneae maturescentes, cum appendicibus 6-8 µm longi x 4-6 µm lati vel atriis apicalibus, globosis, refratis. *Substratum* in lignum mortuum, *Sonneratia alba*: *Distributio* Oceanus Indicus (Seychelles).

BIATRIOSPORA MARINA Hyde and Borse, sp. nov

Ascocarps 650-860 µm long x 350-510 µm in diameter, lying horizontal, immersed in the substratum, subglobose to pyriform, solitary or gregarious, black, carbonaceous, ostiolate and papillate. *Papillae* 150-225 µm long x 60-75 µm in diameter, canal filled with periphyses. *Pseudoparaphyses* 0.6-1.7 µm in diameter, numerous, simple, branched, filamentous, hyaline, embedded in a gelatinous matrix. *Asci* 175-400 µm long x 22-40 µm in diameter, eight-spored, cylindrical, long pedunculate, thick-walled, bitunicate (fissitunicate), with an apical apparatus developing in a hymenium at the base of the ascocarp. *Ascospores* 55-82 x 16-25 µm, uniseriate, fusiform, 2-4 septate towards each end, non-septate in the centre, not constricted at the septa, hyaline when immature, becoming brown to dark brown at maturity, and provided at each end with a hyaline, globose refractive chamber or appendage, 6-8 µm x 4-6 µm in diameter. *Substrate* driftwood and mangrove roots in intertidal region of mangrove stand. Collected from mangrove roots of *Sonneratia alba* from Anse Boileau mangrove stand, Seychelles, during January 1984. Distribution Indian Ocean (Seychelles, coast of Maharashtra, India), and South China Sea (Brunei).

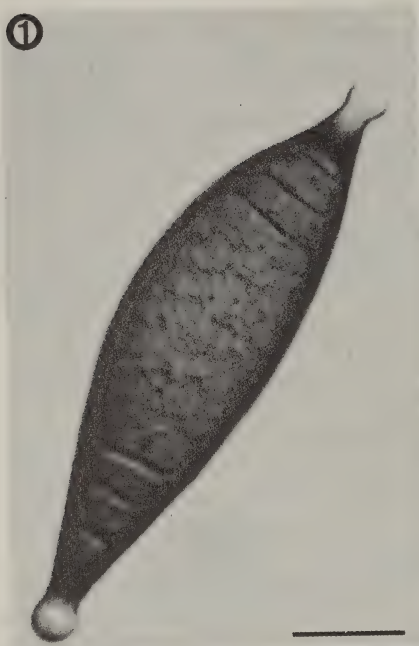
Holotype: *Biatriospora marina* January 2nd 1984, from Seychelles Herb. IMI 297768, slides 1-10.

Isotype: Dried wood from Seychelles

Etymology: From the Latin, *marinus* = marine, referring to the habitat of the species.

Other collections examined: decayed intertidal wood of *Avicennia alba* Bl. MFM No. 61. Revidanda, Maharashtra, 10 October 1981: MFM No. 62 Revdanda, 21 January 1982 on intertidal wood of *A, alba;* MFM No. 63 Revdanda, 21 January 1983 on intertidal wood of *A. alba;* Kampong Doatogandi, Brunei, May 1985 on mangrove wood.

Biatriospora marina belongs to the Ascomycotina, Loculoascomycetes, Loculoedaphomycetidae, Melanommatales (Barr, 1983). *Biatriospora* is characterised by having ascospores with polar globose refractive chambers and polar septa (Figs 1,2). These are unusual features in ascospores of marine fungi, although conical end chambers are characteristic of *Lulworthia* spp. (Kohlmeyer and Kohlmeyer, 1979) and elongate hyaline end cells are present on the muriform brown ascospores of *Aigialus grandis* Kohlm. & Schatz and *A. parvus* Schatz & Kohlm. (Kohlmeyer and Schatz, 1985). A drop of mucilage is released from the end chambers of *Lulworthia*, which is adhesive and aids spore attachment (Rees and Jones, 1984; Hyde, Jones and Moss, 1986). There is also evidence for this in *A.grandis*, where the ascospores have been observed to release a drop of mucilage from the elongated end cells (Hyde, 1985). The refractive end chambers of ascospores of *Biatriospora marina* may also function in attachment, although no evidence for this has been observed.



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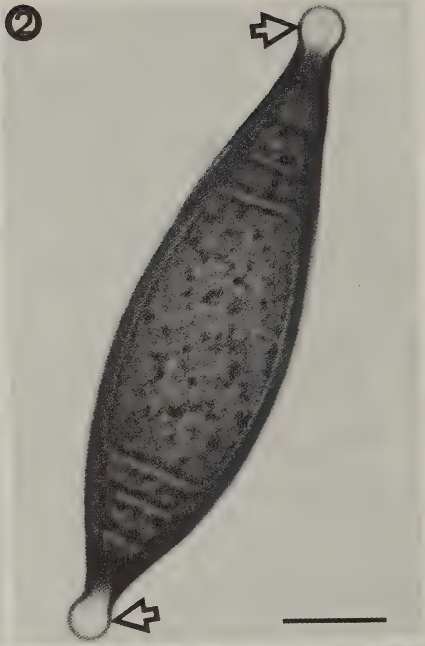

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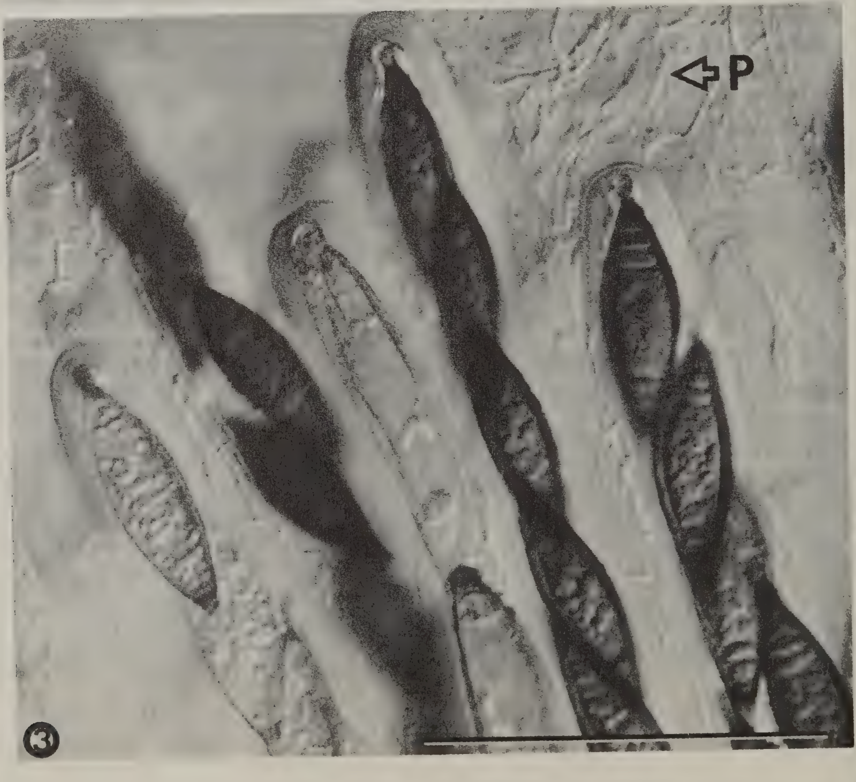

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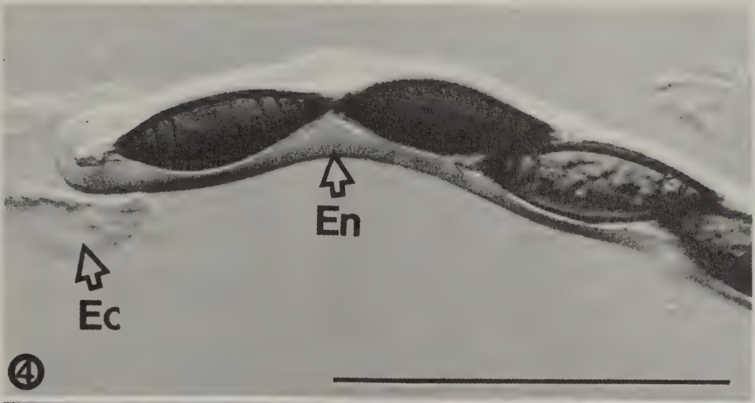
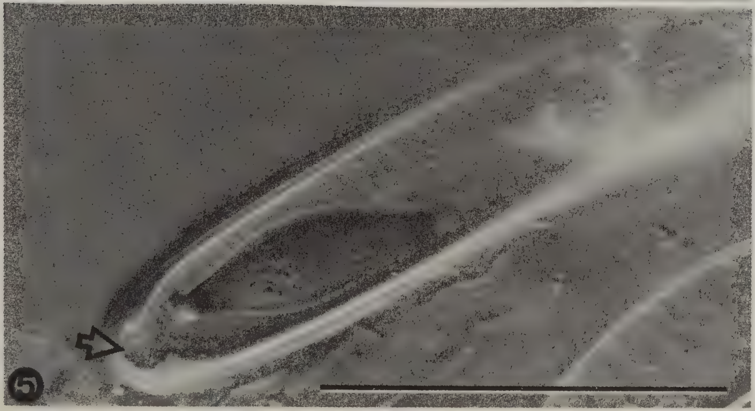




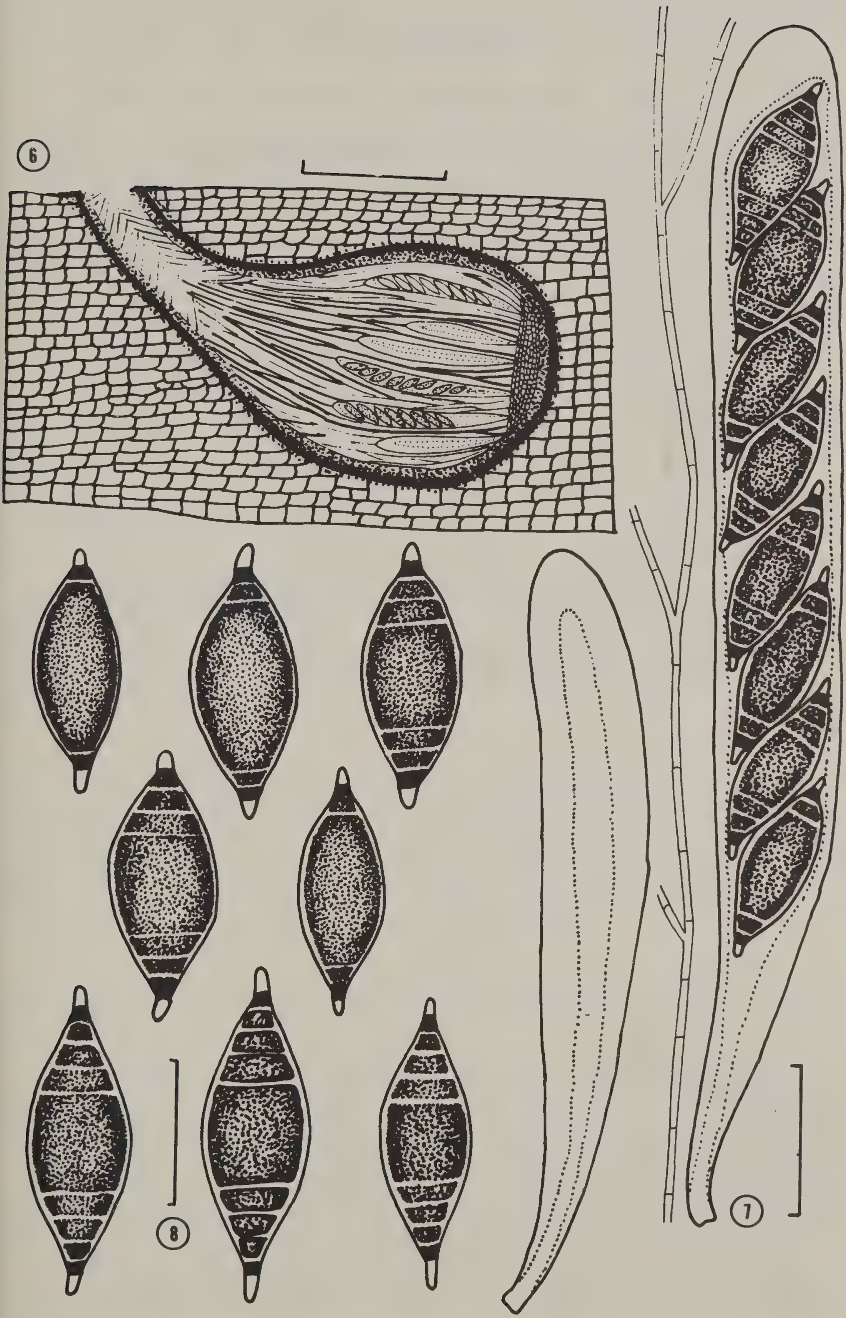
Figs. 1-5. Light micrographs of *Biatriospora marina* . 1,2. Ascospores with hyaline end chambers (2-arrowed). The brown ascospores are septate towards each end and non-septate at the centre. 3. Asci and pseudoparaphyses. Asci are thick-walled with an apical apparatus. Pseudoparaphyses are thin, branched and embedded in a gelatinous matrix (arrowed-P) - 4. Bitunicate ascus. Ascospores are released by rupture of an outer less extensible ectoascus (Ec) and stretching of an endoascus (En). 5. Apical apparatus of ascus (arrowed). Barlines : 1,2 = 10 μm; 3-5 = 100 μm.

Four collections of *Biatriospora marina* were made in Seychelles, which was 0.53% of samples supporting marine fungi, and is thus regarded as occasional in occurrence (Hyde, 1986: referred to as Ascomycete No.6). It is an obligate marine fungus and occurred in association with other marine organisms (i.e. algae, fungi, wood borers).

ACKNOWLEDGEMENTS

K.D. Hyde is grateful for the award of an SERC studentship, and to Ciba-Geigy A/S, Basle for financial support to visit the Seychelles. We are indebted to C. Derrick for photographic assistance, P. Crook for assistance in the Seychelles, Mrs Monica Heywood-Kenny for the Latin diagnosis and to Professor E.B.G. Jones for reviewing the manuscript. B.D. Borse is indebted to Professor S.D. Patil for his benevolent guidance and laboratory facilities.

Figs 6-8 Line drawings of *Biatriospora marina*.
6. Section through ascocarp showing asci and pseudoparaphyses. 7. Asci and pseudoparaphyses. 8. Ascospores.
Barlines : 6 = 200 µm; 7 = 40 µm; 8 = 30 µm.



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MYCOTAXON

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NEW COMBINATIONS IN THE GENUS POSTIA FR. (POLYPORACEAE)

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SUMMARY

The genus Postia (Polyporaceae) is regarded as the appropriate taxonomic unit for brown-rot fungi with a monomitic hyphal system. Its species have been previously described or included in Polyporus, Poria, Fibroporia, Tyromyces, Leptoporus, Oligoporus, Ceriporiopsis, and Amylocystis. Eight new combinations are proposed in Postia.

Jülich (1982) used the generic name Postia Fr. (1874) for poroid fungi with a monomitic hyphal system, clamp connections, metachromatic hyphae in Cresyl Blue, and brown rot of woody substrates. He also made numerous new combinations in the genus. In contrast to Jülich's (1982) application of Postia, Gilbertson and Ryvarden (1985) adopted Oligoporus Bref. (1889) for the same group of fungi, and in similar fashion provided numerous new combinations in that genus.

We interpret the status of Postia as being validly published, priorable, and the correct generic name for the group of poroid fungi in question.

When Fries (1874) introduced Postia, it was clear that his intent was not to provide merely a provisional name. In the Hymenomycetes Europaei (p. 522-523), he mentions briefly his new genus Postia which he says is different from Polyporus, Polystictus, and Trametes, and which he discusses with Daedalea on page 586. Here, Fries again identifies his new genus, provides a diagnosis, and identifies, by species number in the text under Polyporus, names of six species [including Polyporus lacteus Fr., the designated type species (see Donk 1960)]. Thus, all the criteria for valid and effective publication are met. The fact that Fries (1874) did not use *Postia* in a binomial for any of the six cited species does not affect the effective and validly published status of *Postia*.

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[1] Maintained at Madison, WI, in cooperation with the University of Wisconsin.

Karsten took up the Friesian name twice. Once in 1879 when he made the combination *Postia borealis* (Fr.) Karst., and again in 1881 when he wrote "Fam. II--Polyporaceae"..."IV. *Postia* Fr." He accepted three of the original names included by Fries: *P. lacteus*, P. *trabeus*, and *P. weinmanni*. In addition he made three other combinations in *Postia*.

Donk (1960) provided a lucid account of *Postia* and concluded "[*Postia*] appears to be the correct name for the genus that is now called *Tyromyces* P. Karst. or *Leptoporus* Quél. Of the latter two, *Tyromyces* is the 'more correct' name and the one most often used (outside France)." Donk's (1960) only objections to the use of *Postia* instead of *Tyromyces* were (1) the creation of numerous new combinations, and (2) the necessary introduction of a new name for *Postia* Boiss. et Blanch. in Boiss. (1875) (Compositae). Donk (1972) reaffirmed his opinion, and Domanski *et al*. (1967) adopted a similar position.

We agree with Donk's (1960) conclusion that *Postia* is validly published and priorable, and with Jülich's application of *Postia* to names representing certain brown-rot fungi.

In addition to those names already placed in *Postia* by Fries (1874), Karsten (1879, 1881) and Jülich (1982), the following combinations are proposed:

Postia amara (Hedgc.) comb. nov.
Basionym: *Polyporus amarus* Hedgc., Mycologia 2:155. 1910.

Postia angulopora (M. Lars. et Lomb.) comb. nov.
Basionym: *Fibroporia angulopora* M. Lars. et Lomb., Mycologia 75:624. 1983.

Postia mappa (Overh. et Lowe) comb. nov.
Basionym: *Poria mappa* Overh. et Lowe., Mycologia 38:210. 1946.

Postia perdelicata (Murr.) comb. nov.
Basionym: *Tyromyces perdelicatus* Murr., Mycologia 4:95. 1912.

Postia placenta (Fr.) comb. nov.
Basionym: *Polyporus placentus* Fr., Öfers. K. Vet. Ak. Förh., p. 30. 1861.

Postia rancida (Bres.) comb. nov.
Basionym: *Poria rancida* Bres., Fungi Trid. 2:96. 1900.

Postia sequoiae (Bonar) comb. nov.
Basionym: *Poria sequoiae* Bonar, J. Forest. 29:377. 1931.

Postia salmonicolor (Berk. et Curt.) comb. nov.
Basionym: *Polyporus salmonicolor* Berk. et Curt., Hooker J. Bot. 1:104. 1849.

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TYPE STUDIES ON SEVERAL AGARICS DESCRIBED BY F.W. JUNGHUHN

(II)

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Summary

In our studies concerning the type specimens of four agarics described by F.W. Junghuhn (1830) we obtained the following results:

Inocybe brunneovillosus (Junghuhn: Fr.) c. n. is the correct name of *Inocybe cervicolor* (Pers.) Quél.; *Agaricus chloroticus* Junghuhn is a synonym of *Mycena polygramma* (Bull.: Fr.) S.F. Gray; *Agaricus friesii* Junghuhn is a superfluous name, typified with the type of *Tricholoma sejunctum* (Sow.: Fr.) Quél.; *Agaricus tomentosus* Junghuhn is a later homonym of *Agaricus tomentosus* Bull., *Agaricus* (*Inocybe*) *tomentellus* Fr. is a nom. nov. for *Agaricus tomentosus* Junghuhn; *Agaricus tomentellus* Fr. and its nomenclatorial synonym *Agaricus tomentosus* Junghuhn are taxonomical synonyms of *Hebeloma strophosum* (Fr.) Sacc.

F.W. Junghuhn's collection of fungi which is on deposit at the Herbarium of the University of Halle (HAL) unfortunately is not complete. It contains, however, a certain number of type specimens of agarics described by Junghuhn in Linnaea (1930). Three of those taxa we have dealt with in a recently published paper (Dörfelt & Zschieschang 83). In the present publication four additional agarics are described, the type specimens of which we discovered in the Junghuhn herbarium. As the material, at least partly, is not in the best condition, we gave the greatest care to its examination.

Agaricus brunneovillosus Junghuhn

Junghuhn (1830, p. 401-402) described the taxon as follows:

"13. A. BRUNNEO-VILLOSUS mihi. Cervinus, brunneus, / sporidiis brunneis, velo fibrilloso, pileo carnoso explanato / subdepresso floccoso-fibrilloso, lamellis simpliciter adnatis / obscurioribus, stipite floccoso-fibrilloso fistuloso deorsum / attenuato. Tab. VI. f. 5.

Sporidia obscure brunnea. Velum fugax. Pileus / 1 - 2 unc. latus stipiteque floccoso-villosus mollis, carne / lutescente, subconcolore. Lamellae simplices inaequales / 3 lineas latae proprie liberae sed ob stipitis formam in pileum diffusam spurie adnatae s. decurrentes. Stipes in / pileum diffusus, unciam longus, 3 lin. crassus, strictus, / firmus, deorsum attenuatus. Odor saporque dulces.

Gregarium in terra nuda in sylvis Hercyniae inveni. / Septbr."

In Junghuhn's herbarium we found a package with a description in writing which agrees remarkably with the description given by Junghuhn in Linnaea. The characters of the specimen likewise correspond very well with the description just mentioned. Therefore we regard the collection as type specimen of Agaricus brunneovillosus Junghuhn. Already Schmid (1929) considered the specimen as A. brunneovillosus. The label reads as follows:

"Agaricus / Spor. obscure brunnea. Velum / fibrillosum fugax. / A. cervinus, pil. carnoso-expl. subum- / bonato floccoso-fibrilloso, lam. simpl. / inaeq. simpliciter adnatis obscurioribus, / stipite aequali floccoso-fibrilloso-fistuloso, / Sept."

The specimen which is relatively well preserved consists of two carpophores and a spore deposit on paper. The stipes of the fungi are slightly fibrillosus, the pilei are more distinct fibrillous-scaly. The carpophore are partly covered with hyphae to slightly reniform, mostly 10-12 / 6-8 µm, rarely up to 12,5/8,5 µm, hardly less than 10 µm long (e.g. 9,2/5,8 µm). Cystidia not seen. Spore dust abundant, ochraceous. The reproduction of the spore deposit (Junghuhn 1830, tab. VI, fig.5), as well as the term "obscure brunnea" would suggest darker colors. This is an impotant fact with regard to the valuation of other names created by the author, particulary if no type specimen is preserved.

Taxonomic position: On account of the macroscopic characters, as well as the broad spores we are convinced that Inocybe cervicolor (Pers.) Quél. has been described as Agaricus brunneovillosus by Junghuhn. Fries (1836-1838, 1874) equates A. brunneovillosus Junghuhn with A. carptus FR. However, this interpretation accepted by Schmid (1929) cannot be maintained since, among other things, the considerab ly differing spore size makes the two distinct. This and other characters rule out the Friesian species. Perhaps that was suggested by Junghuhn himself who emphasized the structure of the surface of cup and stem on his figure. Oudemans (1892) admits the name Agaricus brunneovillosus. The detailed latin description given by him probably refers to Agaricus cervicolor.

The name Agaricus brunneovillosus Junghuhn is accepted by Fries (1832). Therefore the correct name of the taxon is Inocybe brunneovillosus (Junghuhn: Fries) c. n.; basionym: Agaricus brunneovillosus Junghuhn, Linnaea 5, 1830, p. 401/402.

Agaricus chloroticus Junghuhn

Junghuhn (1830, p. 396-397) described the taxon as follows:

"4. A. CHLOROTICUS mihi. Albus, sporidiis albis, velo / nullo, pileo submembranaceo campanulato laevi ambitu / sulcato-striato, lamellis liberia utrinque subaequalibus dein / incarnatis, stipite striato longo fistuloso basi strigoso radicato. Tab. VII. f.1.

Albo-subflavescens. Pileus 1/2 - 1 unc. latus, cam- / panulatus subumbonatus. Lamellae simplices, inaequa- / les 2 lin. latae. Stipes subfistulosus, radice excepta, / 3 - 4 uncias longus, 2 lin. circiter crassus, subelasticus, / eximie s. profunde striatus, basi strigosus, radice subin- / crassata profunde in terram intrante.

Odor saporque nulli. A. polygrammus Bull. praeter / physiognomiam longe aliam, differt pileo subcinereo, la- / mellis attenuato-adnexis, (in nostro liberis,) stipite argen- / teo s. caesio etc.

Inveni solitarium in sylvis Herc. sub Corylo. Septbr."

In Junghuhn's herbarium we discovered a collection supplied with the description in writing which we consider as holotype of Agaricus chloroticus. The description just mentioned, as well as the characters of the carpophores agree very well with the description and figure in Linnaea. However, Schmid (1929) did not identify the specimen with Agaricus chloroticus. Apparently he came across several similiar reading descriptions and was not able then to attach one of them to his species, because he determined the existing specimens exclusively by means of philological research. The label reads as follows:

"Agaricus. / Spor. alba. Velum O. Pileus tenui-carn. / A. albus, pileo camp. subumbonato lae- / vi, ambitu striato-plicato. Lam. / simpl. inaeq. lib. demum subcarneis, / stipite longo radicante striato / subfistuloso basi hirsuto./ Octbr."

The collection is in bad condition. It consists of fragments of carpophores, cups, broken stems, partly demaged by insects. We tried to "reconstruct" three carpophores by joining the fragments. The lamellar trama is regular, mature spores were found in some few preparations only, spore size 8,6-9,6/5,5-6,7 µm.

Taxonomic position: *Agaricus chloroticus* Junghuhn is a synonym of *Mycena polygramma* (Bull.: Fr.) S.F. Gray. However, there is a discrepancy between the date noted on the label and the date stated in the description published by Junghuhn. Certainly a mistake occured when Junghuhn copied the text. Therefore we are convinced that the description in Linnaea is based on the specimen cited above. The stration of stems, spore size, description, as well as the figure demonstrate that it cannot be separated from *Mycena polygramma*, in spite of the color of gills reminding one of *Mycena galericulata*. Both reddish gills and white cups have been observed in *Mycena polygramma*, too. Junghuhn's figure shows an atramentarieous carpophore. Doubtlessly the colors have darkened during the many years passed away since the paper was published (see Junghuhn's description). Even Fries (1874) attached the species to *Agaricus polygrammus* Bull., in spite of Junghuhn's referring to the differences between *A. chloroticus* and Bulliard's species. However, these differences merely point out the variability of *Mycena polygramma* which is frequent in the area where Junghuhn undertook his collection trips.

Agaricus friesii Junghuhn

Junghuhn (1830, p. 394-395) described the taxon as follows:

" 1. A. FRIESII mihi . Sporidiis albis, velo fibrilloso / fugaci, pileo carnoso convexo umbonato subfibrilloso gri- / seo-nigricante, lamellis liberis emarginatis basi*) emargi- / nato-angulatis, stipite aequali solido fibrilloso-striato albo.

Species maxime varians magnitudine, pubescentia, / crescendi modo, colore, odore, forma, - quo factum est, / ut apud auctores diversae unius speciei formae fere tot / diversae species descriptae sint. A. graveolens Pers., A. / sejunctus Sow., A. myomyces Pers., A. virgatus Fr. et / A. gausapatus Fr. in systemate mycologico Friesii distin- / cti ad unam eandemque speciem pertinere persoasum mihi / habeo, pluresque alias jam distinctas formas ejusdem spe- / ciei esse, valde suspicor. Omnium transitus mutuos in / Hercyniae sylvis vidi nec exiguam individuorum copiam / in omni aetatis statu, in quovis loco natali, in apricis, um-/ brosis, pinetis, fagetis etc. observavi. - Pileus 1 - 3 / unc. latus, ambitu semper pallidior, plerumque griseus, ni- / gricans, saepe albidus, subferrugineus, lutescens, innato / fibrillosus, fibrillis tomentum densum formantibus, jove / pluvio saepe in flocculos coalitis. Nonnisi in junioribus / abradi possunt, si quidem pilei substantiam laedere nolis. / Variat glabriusculus, adpresse squamosus.

Caro albo, / firma. Lamellae simplices, inaequales 2 - 3 lineas la- / tae, crenulatae, medio emarginatae, basi constanter angu- / lato-emarginatae, angulo obtuso, rarius subacuto. Non- / nunquam situm obliquum habent. Stipes 1 - 3 unc. lon- / gus, 2 lin. - 1/2 unc. et ultra crassus, striatus h. e. fibril- / losus fibrillis cum stipite homogeneis concretis, medio / subaraneosus. In loco praecipiti curvatus, adscendens / evadit.

Varietates frequentiores occurrunt:

1. Pileo laevi medio verrucoso, stipite squamuloso / squamulis adpressis.- Sordidus livido-subcinerascens.

2. Pileo laevi nidito venoso-virgato, venis obscurio- / ribus. Haec forma praesertim autumno seriori occurrit, / post multas pluvias demissas, quo saepe magna fibrillarum / pars abluitur. Fibrillae concretae sunt, tantum venae ap- / parent!

3. Pileo brunneo-lutescente, lamellis stipiteque laete luteis.

Odor saporque non constantes. Odor plerumque fa- / rinae recentis, subrancidus, sed in eadem varietate saepe / nullus. - Plerumque gregarius occurrit, saepe caespito / sus, quo pileus haud raro irregularis, depressus, (repan- / dus) evadit.

*)Eam lamellarum partem, qua ad stipitem vel spectant vel eo / adnatae sunt, basin, - huic oppositam, s. finem earum, apicem, - / eam qua cum pileo concretae sunt, dorsum, - huic denique opposi- / tam, aciem lamellarum apello."

This description which is based doubtlessly on several collections, includes a number of species which are autonomous in the sense of modern taxonomy. In Junghuhn's herbarium we found a specimen which belongs to the original material the description relies on. This results from the features of the exsiccatum, as well as from the notes on the label. Even Schmid (1929) identified the specimen as Agaricus friesii Junghuhn. The mentioned notes read as follows:

"Agaricus ?gausapatus Fr. / Syst. I/43. / Spor. alba. Velum fibrillos. alb. / A. pileo convexo explanato umbonato / griseo-nigricante s. albido innato- / fibrilloso, lam. simpl. inaequ. lib. / albis s. cinereis, stipite aeq. solido / firmo fibrilloso albo. / Odor foetis rancidus. / (wie verdorbenes dumpfiges Mehl !)"

The collection includes eight carpophores and some few fragments. The fungi are brown and strongly covered with hyphae of imperfect fungi. Basidiospores 6-7/4,5-5 µm. The observed characters and the notes on the label do not render possible an unambiguos determination.

Taxonomic position: Under the name Agaricus friesii Junghuhn summarized several autonomous species. Since Junghuhn mentions earlier legitimate names as synonyms, according to the ICBN art. 63 (Stafleu et al. 1978) *A. friesii* is a superfluous name. Corresponding to our rules of nomenclature, Junghuhn had to adopt one of the names cited by him, instead of creating a new one. Concerning the typification we must follow art. 7.11. By nomenclatural reasons we are not allowed to follow Fries who quoted *A. friesii* as a synonym of *A. (Tricholoma) terreus*. The examined sample probably belongs to *Tricholoma terreum* or *T. scalpturatum*. There is no doubt that Junghuhn includes both *Tricholoma terreum* and *T. scalpturatum* (see var. 3 !) in *A. friesii*, however, without citing them as synonyms. Consequently these names are not applicable for the tyfication of *A. friesii*. According to art. 7.11, the type of the superfluous name *A. friesii* is automatically the type of that name which had to be adopted by Junghuhn. Since they had been published in Systema Mycologicum (Fries 1821), the five names cited by Junghuhn are protected names. According to the principle of priority, the type of the earliest of these names, *Agaricus sejunctus* Sowerby 1798: Fr. is automatically the type of *A. friesii*. The other names are of later date (*A. graveolens* Persoon 1801: Fr.; *A. myomyces* Persoon 1801: Fr.; *A. virgatus* Fries 1818: Fr.; *A. gausapatus* Fries 1821.

Agaricus tomentosus Junghuhn

Junghuhn (1830, p. 403) described the taxon as follows:
"16. A. TOMENTOSUS mihi. Sporidiis brunneis, velo / fibrilloso persistente, pileo carnoso convexo brunnescente / fibrilloso-tomentoso, lamellis dilute brunneis margine al- / bidis simpliciter adnatis acie subrectis, stipite aequali so- / lido firmo striato-fibrilloso supra velum pruinoso. Tab. / VI. f. 7.
Sporidia obscure brunnea. Velum fibrillosum, album, / subpersistens, in superiori stipitis parte annulum tomen- / tosum, spurium constituit. Pileus unciam et ultra latus. / Lamellae 4 lin. latae, simplices, inaequales. Stipes in / pileum diffusus 1 1/2 unc. circiter longus, 4 lin. crassus.
In sylvis Hercyniae inferioris passim."

In Junghuhn's herbarium is a collection which agrees very well with both the notes on the label and the description in Linnaea. Schmid (1929, p. 9, see nr. 122) did not recognize this, because the description published in Linnaea, was modified and supplemented by the author in some details. This collection must be regarded as holotype of *Agaricus tomentosus* Junghuhn. The description on the package reads as follow:

"Agaricus / Spor. obscure brunnea. Velm [!] araneosum / fugax album / A. pileo carn. convexo-explanato ferru- / gineo subrufescente margine reflexo / pallidiore albido centro subhumido / nitente ambitu arenoso-fibrilloso, / lam.

simpl. inaeq. simpliciter adnatis / albidis mox brunneis, stipite / aequali fistuloso albido fibrilloso."

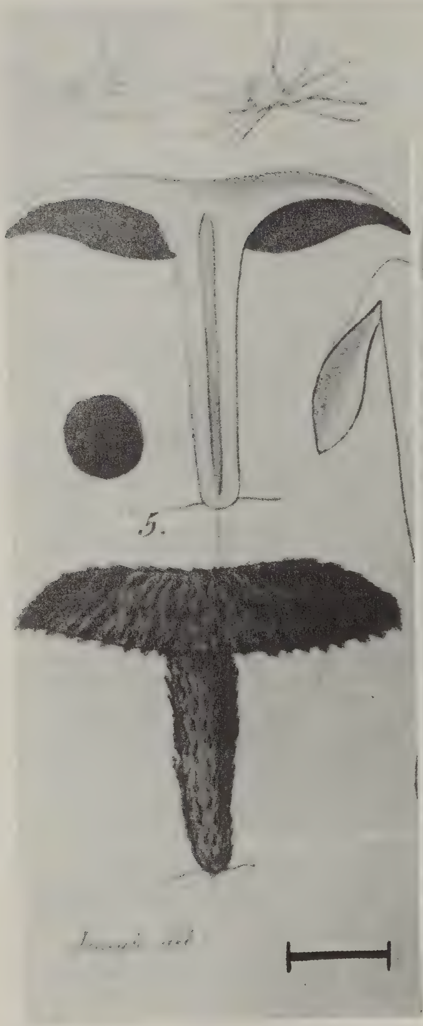
The collection includes seven well preserved carpophores and a spore deposit on white paper, showing deep ochraceous spores. Carpophores brown, pileus with darker center, more pallid at margin. Lamellae chocolate brown, edges white. Spores (9,5-) 10-10,8 (-11,2)/(5,5-) 6-6,5 (-7) µm.

Taxonomic position: Fries (1836-1838) recognized A. tomentosus Junghuhn as an autonomous species. Because of the earlier homonym A. tomentosus Bulliard /=Coprinus tomentosus (Bull.: Fr.) Fr./, he created a nomen novum for this fungus, Agaricus tomentellus Fries. Therefore A. (Inocybe) tomentellus Fr. must be typified by original material of A. tomentosus Junghuhn. The description of A. tomentellus is based on Junghuhn's description of A. tomentosus. The only figure Fries cites is that of Junghuhn. Ricken (1915) thought the species probably identical with Agaricus (Hebeloma) strophosus Fries. Fries (1836-1838) had described A. strophosus as a species of the "Tribus" Hebeloma. Later on (1874) he placed it near to Agaricus (Hebeloma) mesophaeum, in keeping A. (Inocybe) tomentellus as an independent species. The mycological authors of the following decades seldom cited A. tomentellus Fr. (= A. tomentosus Junghuhn) in the sense of Fries, i.a. as a species be-longing in Inocybe. In our opinion Hebeloma strophosum (Fr.) Sacc. is identical with Agaricus tomentellus Fr. (= tomentosus Junghuhn), as previously supposed by Ricken. According to Ricken H. strophosum has larger spores than H. mesophaeum. It seems highly doubtful that H. strophosum in the sense of Lange (1938), Moser (1978), Kühner & Romagnesi (1953) is identical with A. strophosus sensu Fries, as well as in the sense of Ricken, since their species differs not only in having smaller spores, but also by lack of the darker pileus center emphasized by Fries.

The type of A. tomentosus Junghuhn agrees very well with Fries' and Ricken's description of A. strophosus. Fries did not recognize A. tomentosus and A. strophosus beeing identical. This may arise from the fact that Junghuhn's figure does not show the darker pileus center which is yet visible at the dried specimens. The color of the spore deposit has been depicted too dark and does not agree with the color of the spore powder enclosed to the type specimen.

Acknowledgement

We are very grateful to Dr. S. Rauschert, Halle, for directions concerning problems of nomenclature, as well as for critically reading the manuscript and making helpful suggestions. We are also much indebted to Dr. K. Werner, Custodian at the Herbarium of the University of Halle (HAL), for his assistance.



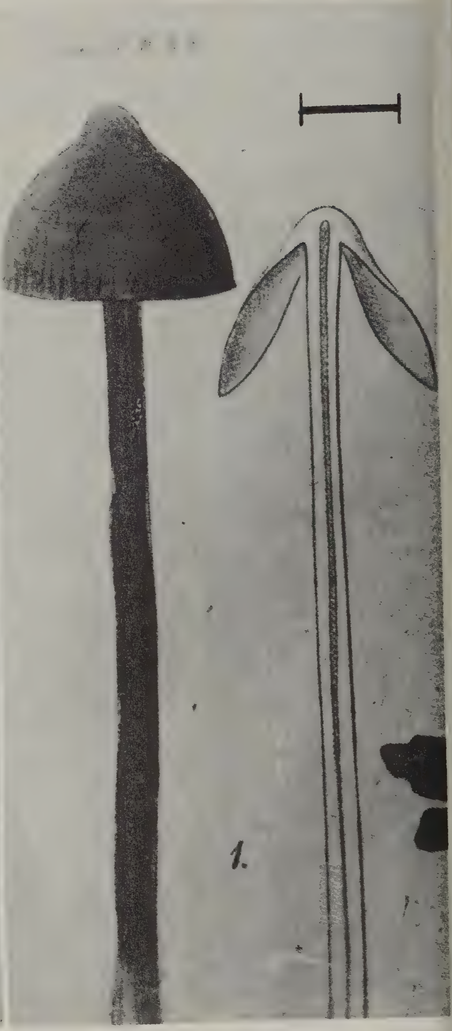
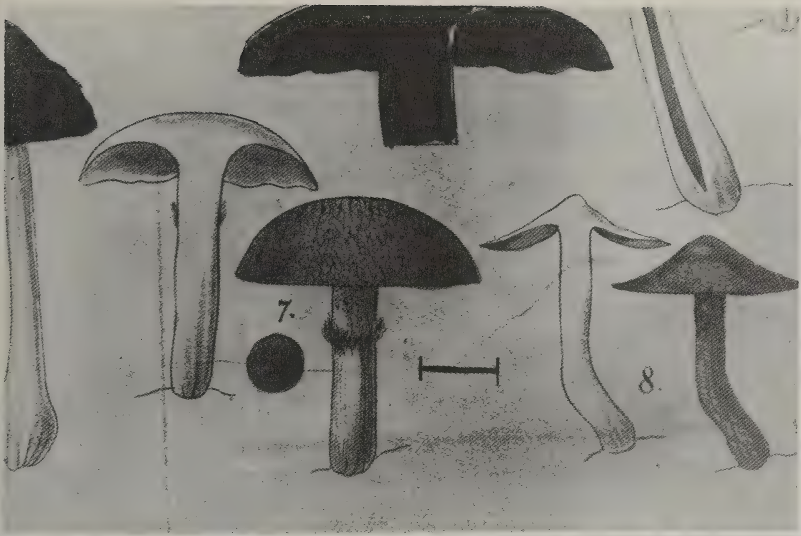


Fig. 1 Agaricus brunneovillosus Junghuhn (left) Linnaea 5 (1830), Tab. VI, fig. 5; standard of comparision: 1 cm

Fig. 2 Agaricus chloroticus Junghuhn (right) Linnaea 5 (1830), Tab. VII, fig. 1; standard of comparisation: 1 cm

Phot. H. Dörfelt



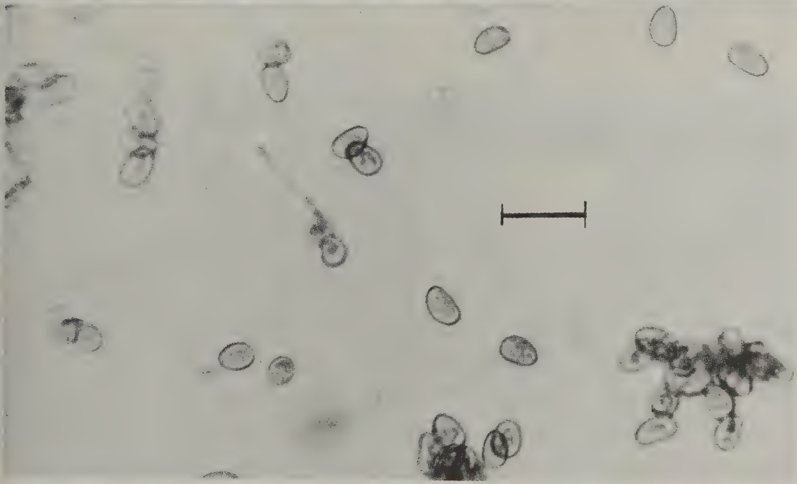
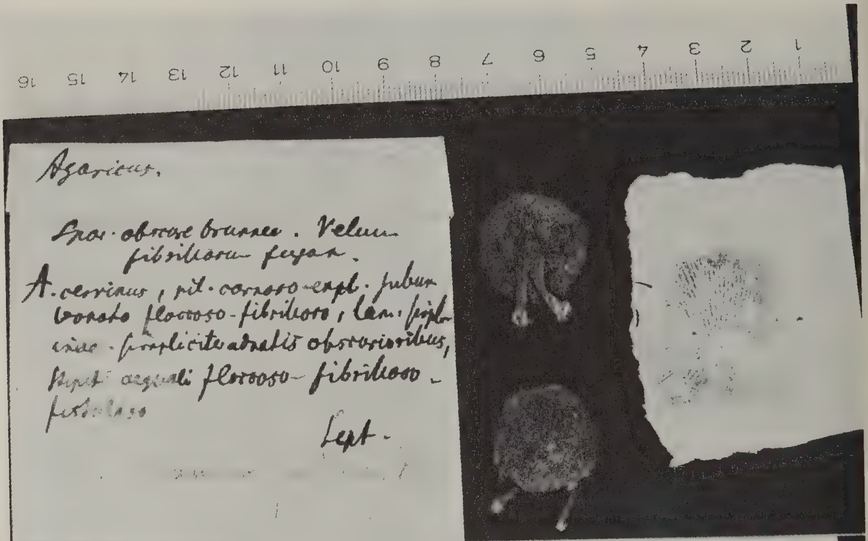


Fig. 3 Agaricus tomentosus Junghuhn (7) and Agaricus sterilis Junghuhn (8, see Dörfelt & Zschieschang 1983, Mycotaxon 17, p. 322)
Linnaea 5 (1830), Tab. VI, figs. 7 and 8; standard of comparision: 1 cm

Fig. 4 Agaricus brunneovillosus Junghuhn
spores of the type specimen; standard of comparision: 20 µm

Phot. H. Dörfelt

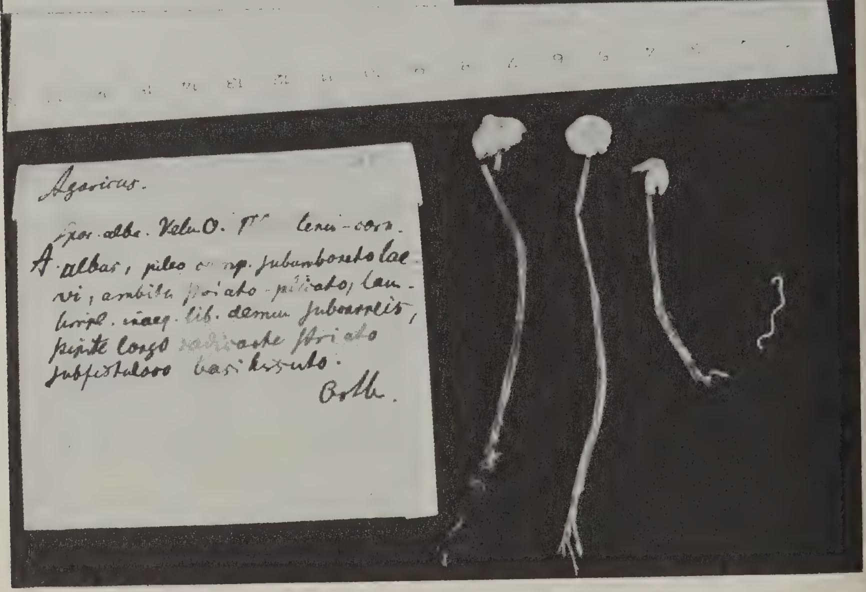


Agaricus.

Spor. obscure brunnea. Velum fibrillosum fugax.

A. cervinus, pil. carnoso-expl. subumbonato floccoso-fibrilloso, lam. simpliciter adnatis obscurioribus, stipit. aequali floccoso-fibrilloso-fistuloso

Sept.



Agaricus.

Spor. albae. Vel. 0. Pil. tenui-carn.

A. albus, pileo camp. subumbonato laevi, ambitu striato-plicato, lam. simpl. inaeq. lib. demum subconnexis, stipite longo radicante striato subfistuloso basi hirsuto.

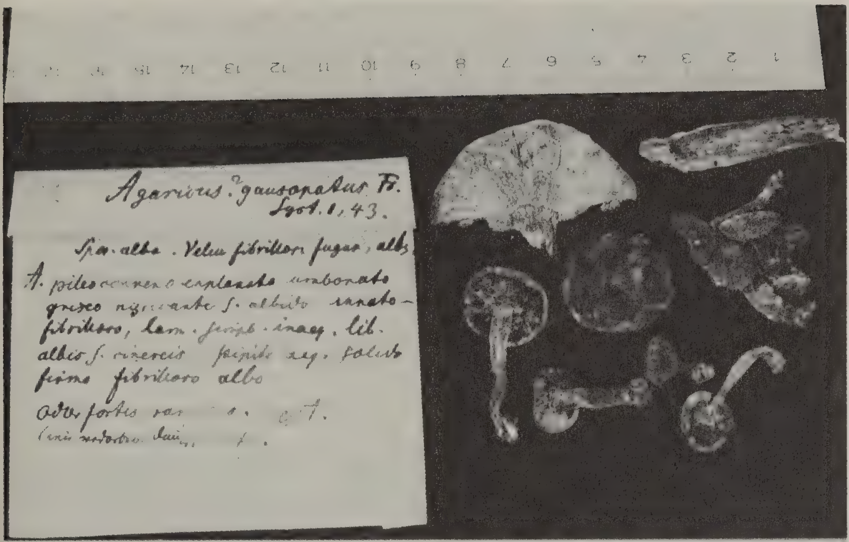
Octb.

Fig. 5 Agaricus brunneovillosus Junghuhn type specimen

Fig. 6 Agaricus chloroticus Junghuhn type specimen

standard of comparision: tape measure

Phot. H. Dörfelt


Agaricus ? gausapatus Fr. Syst. I, 43.
Spor. alba. Velum fibrillosum fugax, album
A. pileo convexo explanato umbonato griseo nigricante s. albido lanato-fibrilloso, lam. confl. inaeq. lib. albis s. cinereis stipite aeq. solido firmo fibrilloso albo

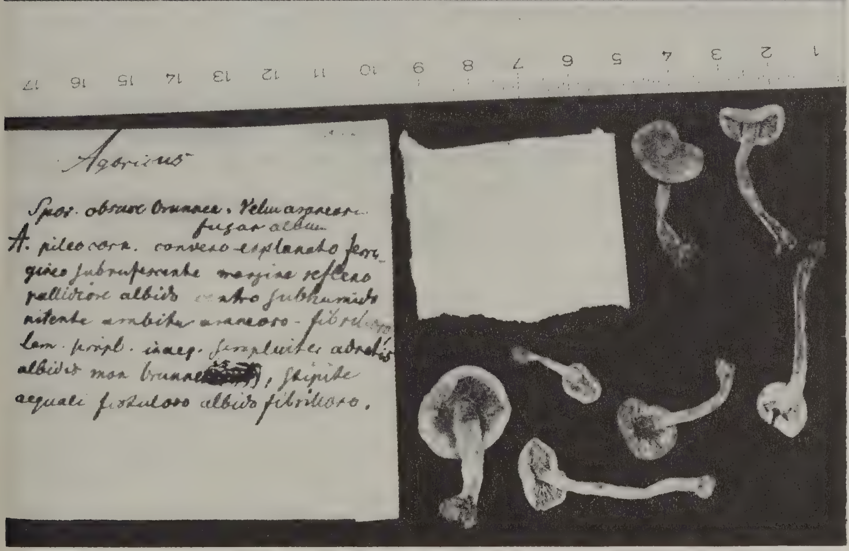

Agaricus
Spor. obscure brunneae. Velum araneosum fugax album
A. pileo carn. convexo-explanato ferrugineo subrufescente margine reflexo pallidiore albido centro subhumido nitente ambitu araneoso-fibrilloso lam. confl. inaeq. simpliciter adnatis albidis mox brunneis, stipite aequali fistuloso albido fibrilloso.

Fig. 7 Agaricus friesii Junghuhn
specimen of herb. Junghuhn, collected by Junghuhn

Fig. 8 Agaricus tomentosus Junghuhn
type specimen

standard of comparision: tape measure

Phot.: H. Dörfelt

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XYLARIA POITEI: STROMATA, CULTURAL DESCRIPTION, AND STRUCTURE OF CONIDIA AND ASCOSPORES

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SUMMARY

Teleomorphic and anamorphic stromata from fresh field collections are discussed. Cultural characters, including anamorphic structures, are described.

The ascospore germ slit is shown to be a channel in a pigmented wall layer into which nonpigmented inner wall material has intruded. The slit is covered by a thick pigmented exterior wall layer.

The conidium bears an apical corona formed by an annular thickening of the outermost wall layer. Its nucleus is highly convoluted and occupies a large portion of conidial volume.

Xylaria poitei (Lév.) Fr. is among the largest of Xylaria species, occurring in southern and southwestern USA and throughout the American tropics. In a recent paper, Rogers (4) redescribed the fungus and discussed some nomenclatural aspects. Unfortunately, fresh teleomorphic stromata or cultures were not available during this previous investigation. During the AIBS meetings of August 1985 at University of Florida, Gainesville, Catherine A. Palm-Gessner found, and helped obtain, a very large fruiting of X. poitei in Paynes Prairie State Preserve, Alachua Co., Florida. This fruiting had both mature and immature teleomorphic stromata and anamorphic stromata in close proximity. Most of the observations and data recorded here come directly from these collections and from cultures initiated from the collections.

OBSERVATIONS ON STROMATA

Mature and maturing teleomorphic stromata up to 15 cm high X 4 cm thick were collected. In the field they were smooth and silvery to tan, becoming blackish with age. Stromata brought into the laboratory and placed on blotting paper or under bell jars began to release ascospores within 24 hr. They also lost a good deal of water, shrinking to about 50% of field diameter and becoming very wrinkled over several days. Thus, stromata are apparently very hygroscopic, more so than most investigated *Xylaria* species. Moreover, this is an essentially smooth species when in prime condition in the field, becoming highly wrinkled with age or drying. This must be taken in account when attempting to identify collections.

Anamorphic stromata of various shapes (Fig. 18) and up to 3 cm high X 3 cm broad were collected from the vicinity of teleomorphic stromata. The identity of anamorphic structures was verified by sampling them for morphologically distinctive conidia (see later). We are uncertain if anamorphic stromata of *X. poitei* eventually develop into teleomorphic stromata or if they represent a separate and distinct state, i.e., as does the *Xylocoremium flabelliforme* (Schw.: Fr.) J. D. Rogers state of *X. cubensis* (Mont.) Fr. (4). Circumstantial evidence favors the latter possibility. First, it is unusual among *Xylaria* species to have conidium-bearing stromata produced at the same time that perithecia are maturing. Even in cases such as *X. hypoxylon* (L.: Fr.) Grev. where perithecia mature in formerly conidium-bearing clavae from the bases

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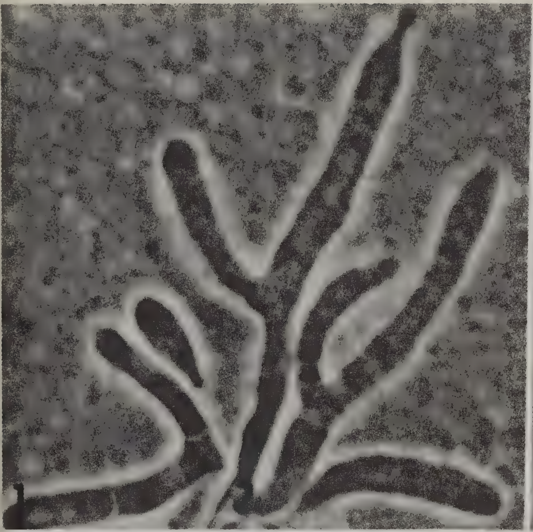
Figs. 1-9. *Xylaria poitei*. 1. Young conidiophores and conidiogenous cells, X 1650. 2. Young conidiogenous cells, the left one beginning to produce its first conidium at the apex, X 1650. 3. Scarred apex (arrows) of conidiogenous cell which has one conidium attached, X 2500. 4. Conidium. Note two apical projections, X 3500. 5. Conidiogenous cells. One conidium (arrow) shows apical projections, X 1650. 6. Conidial hymenium showing conidiophores, conidiogenous regions, conidia, and hyphae from which conidiophores arose, X 1300. 7. Conidia, one still attached to conidiogenous cell. Note corona on one conidium (arrow), X 7000. 8. Scarred conidiogenous region (arrows) bearing terminal conidium, X 6000. 9. Conidiogenous region bearing conidium, X 5000.

Figs. 1, 3, 4 from mounts on Double Stick Scotch brand tape in lactophenol by darkfield phase contrast microscopy. Figs. 2, 5 mounted as above, by differential interference microscopy. Figs. 6-9 by scanning electron microscopy.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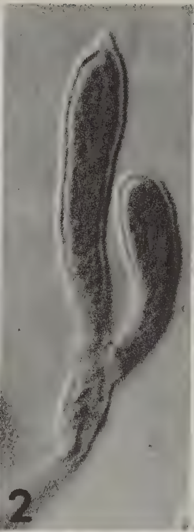
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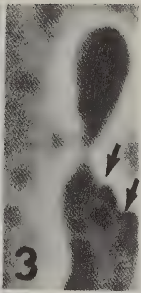
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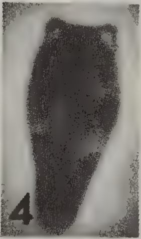
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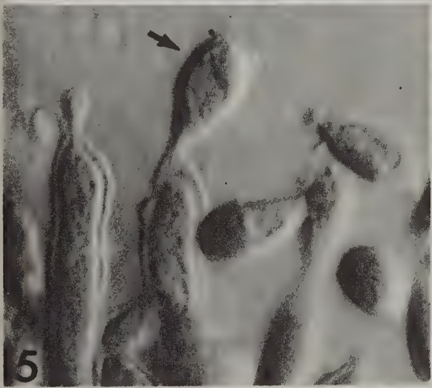
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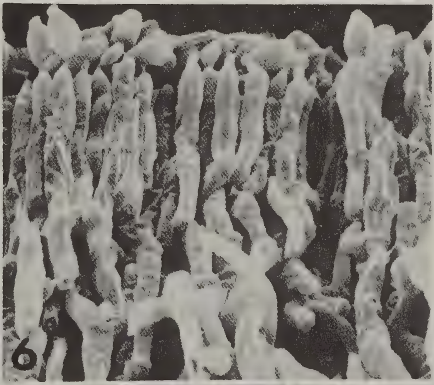
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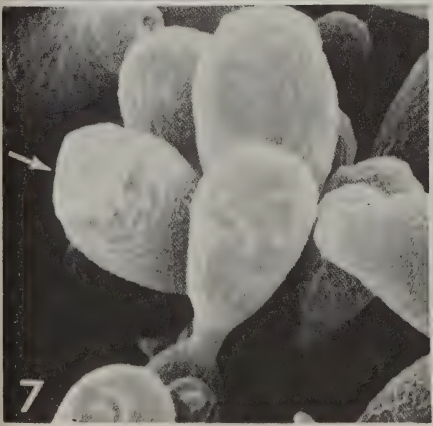
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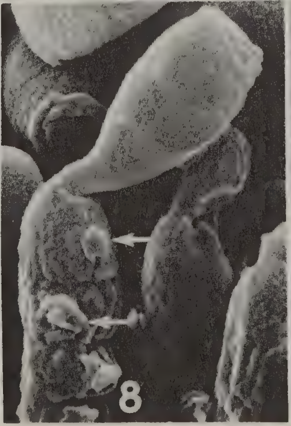
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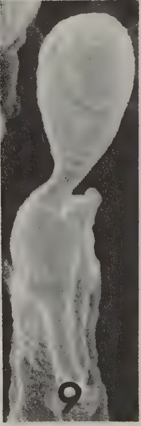
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upward, the greatest period of conidial production seems to be before the maturation of even the perithecia located nearest to the stipe. Second, anamorphic stromata of X. poitei are convoluted and sometimes hollow and do not resemble teleomorphic stromata. In X. longipes Nits., however, teleomorphic stromata develop by enlargement from small anamorphic structures that bear little resemblance to the maturing teleomorphic stromata. In any case, field observations throughout a season of development are necessary before the facts of stromatal development are clear.

STRUCTURE OF THE ASCOSPORE WALL

The ascospore of X. poitei has been described previously (4). Its germ slit is easily seen by light microscopy. Sections of ascospores examined by transmission electron microscopy (TEM) reveal three major wall layers: an innermost electron-transparent layer and two electron-dense outer layers (Figs. 11 and 12). Scanning electron microscopy (SEM) of fractured ascospores corroborates the TEM observations (Fig. 15). Sections through the germ slit show that the slit is, in reality, a longitudinal channel which is the result of the localized failure of synthesis of the middle pigmented wall layer (Fig. 11). Wall material from the interior layer protrudes into the channel (Fig. 11). The germ slit is not visible by SEM on dormant ascospores. It can be seen indistinctly on ascospores from which the outermost layer has been mechanically removed (Fig. 14). Presumably, this outermost layer ruptures as the ascospore swells prior to

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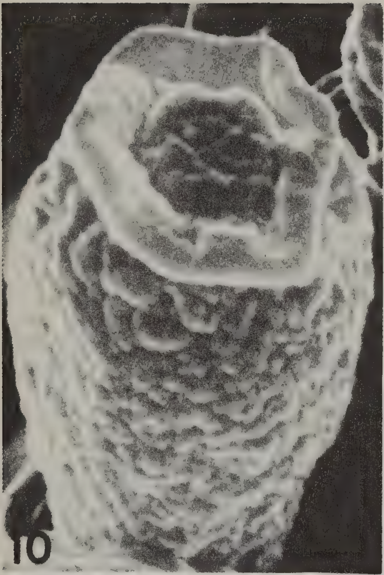
Figs. 10-15. Xylaria poitei. 10. Portion of conidium showing apical corona, X 18000. 11. Cross-section of ascospore walls through the germ slit showing wall layers A, B, C. Note that innermost wall layer C protrudes into the area where wall layer B is lacking, X 34700. 12. Section showing wall layers A, B, C. Dark area between A and B is a separation between these layers, X 36000. 13. Longitudinal section of conidium, showing convolutions of nucleus (n) and portion of corona (arrows), X 13000. 14. Ascospore from which outermost wall layer A was removed. Germ slit is faintly visible (arrow). White material beneath arrow is debris, X 7000. 15. Fragment of ascospore with wall layers A, B, C exposed, X 7000.

Figs. 10, 14, 15 by scanning electron microscopy. Figs. 11-13 by transmission electron microscopy.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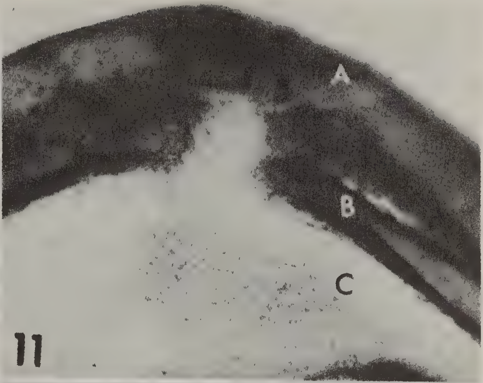
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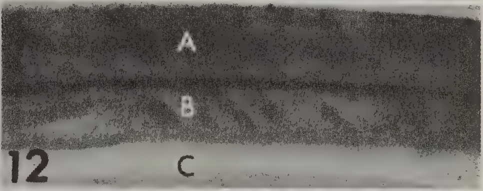
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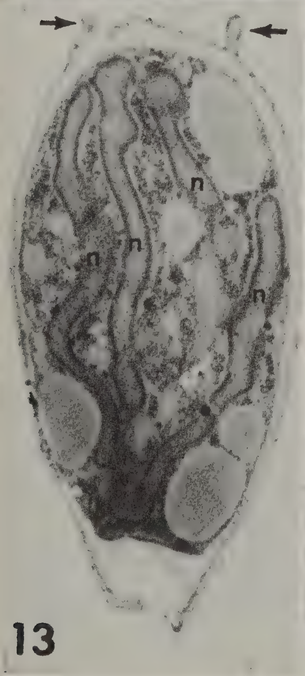
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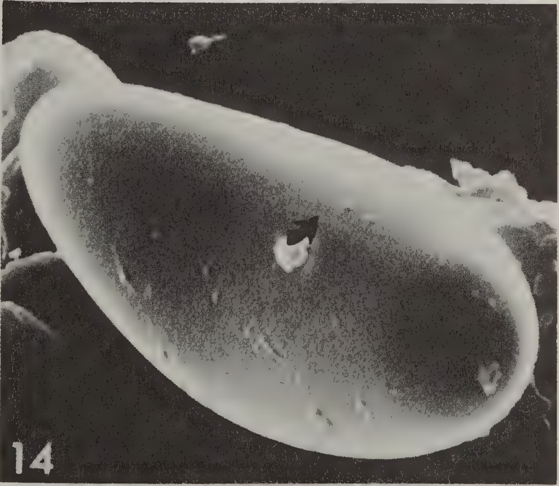
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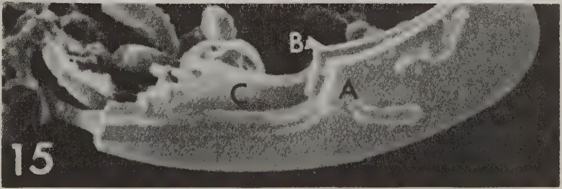
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germination and, at that time, the slit would be conspicuous by SEM, e.g., in the manner of those of Daldinia concentrica (Bolt.: Fr.) Ces. & DeNot. as shown by Beckett (1,2). The D. concentrica ascospore seems to have several more layers than that of X. poitei, including a thick hyaline outer layer (perispore) that dehisces as pregermination swelling begins (1). No attempt is made herein to equate the wall layers of the X. poitei ascospore with those of D. concentrica (1). In general, the germ slits of these two fungi seem very similar in structure.

CULTURAL PHENOMENA

Newly ejected ascospores were streaked onto plates of various nutrient media. A few ascospores germinated on various media after one week and colonies resulted.

Xylaria poitei (Lév.) Fr. Culture and anamorph.

Colonies on 2% oatmeal agar (Difco) at ca. 22 C under varying laboratory fluorescent light and dark periods growing restrictedly, not covering 9 cm diam Petri plate in 4 wk, at first white to beige, becoming blackened from center outward, with surface mycelium appressed, producing 1-several stromata in central part. Stromata cylindric to clavate, unbranched or branched, up to 5 cm X 0.5 cm diam (much longer when grown in less confining culture vessels), gray to brownish-gray, dusty from conidia, eventually becoming hollow (Fig. 19). Reverse uncolored.

Conidiophores covering entire stromata, arising from loose underlying network of generative hyphae (Fig. 6), sparingly branched, hyaline, smooth, 37-60 X 3-4 μm (Fig. 1). Conidiogenous regions apical, hyaline to subhyaline, cylindrical to clavate, 7-23 X 4-5 μm, at first smooth, but coming to bear raised crateriform or denticulate conidial secession scars (Figs. 1,2,3,5,6,8,9). Conidia produced holoblastically in more or less sympodial sequence. Conidia hyaline, minutely roughened, essentially obovoid, 6-10(-13) X 3-6(-6.5) μm, often with concave or truncate or winged apex as seen with light microscopy

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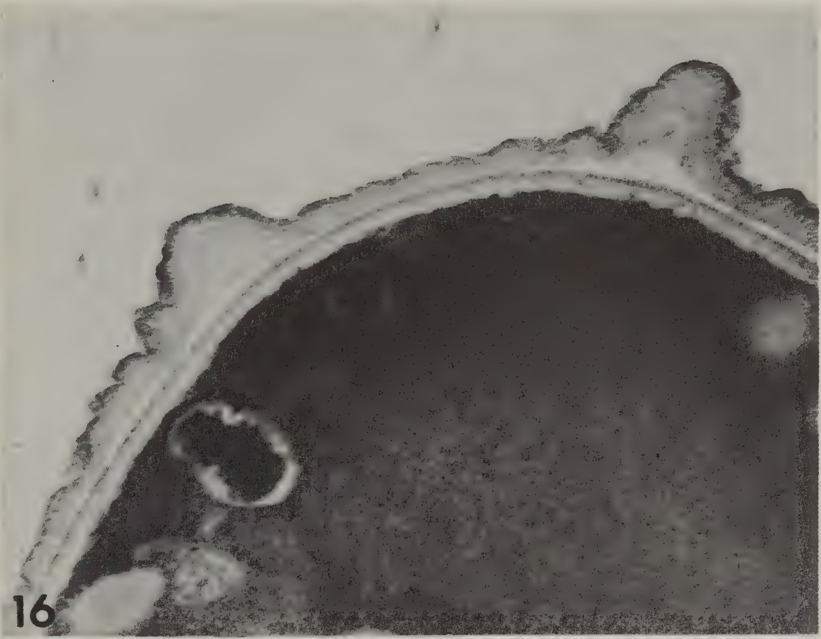
Figs. 16 and 17. Xylaria poitei. 16. Section through apical region of conidium showing projections of corona which represents a thickening of the outermost wall layer, X 40000. Fig. 17. Section of convoluted conidial nucleus similar to that in Fig. 13. Double membrane is apparent in various places, X 37500.

Figs. 16 and 17 by transmission electron microscopy.



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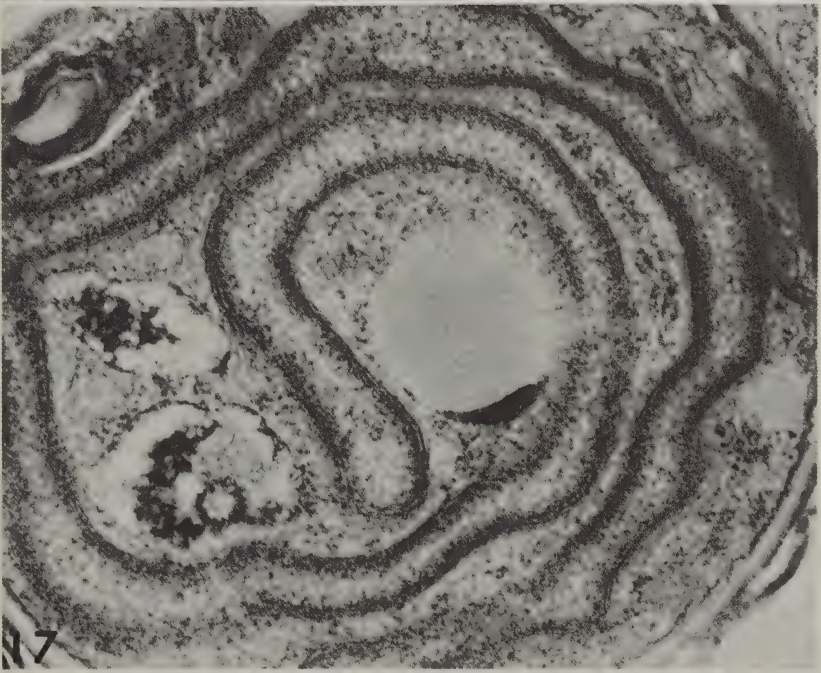

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(Figs. 4 and 5), but shown by scanning electron microscopy to be an apical corona (Figs. 7,10), with bases flattened indicating former attachment to conidiogenous cells (Figs. 4,13). A few conidia (probably less than 10%) germinating after 2-7 days, giving rise to typical colonies.

STRUCTURE OF THE CONIDIUM

The X. poitei conidium has two wall layers; the corona originates as an annular thickening of the outer one (Figs. 13,16). We do not know of a function for the corona. Conidia apparently do not adhere to substrates by it. Likewise, conidial germ tubes do not originate from within the corona any more frequently than elsewhere on the conidium. It is not certain that every conidium bears a corona. The apices of some appear devoid of it when viewed by light microscopy. In any case, the X. poitei conidium is the only xylariaceous conidium known to us to have a corona.

The conidium contains a single nucleus in a highly convoluted configuration (Figs. 13,17). Roe (3) has elegantly shown similar configurations in conidial nuclei in a number of other Xylaria species. We hypothesize that the conidium of X. poitei is primarily a carrier for a nucleus and might function, or have functioned in the past, as a spermatium. It is possible that complex nuclear configurations allow the packaging of a relatively large volume of nuclear material that can be unwound during a fertilization process. Moreover, the large volume of nuclear material might explain both the relatively low germination percentage of conidia and the relatively long period required for significant numbers of conidia to germinate. Nuclear material seemingly occupys conidial volume at the expense of organelles involved with germ tube wall synthesis and we suspect that many conidia are unable to germinate owing to a deficiency of metabolic organelles. We suppose that the lag time between the sowing of conidia on nutrient agar and the germination of relatively few is related to the paucity of metabolic organelles even within those that ultimately germinate. In any case, X. poitei conidia must be viewed as potential propagules regardless of other past or present functions.

Figs. 18 and 19. Xylaria poitei. 18. Anamorphic stromata from vicinity of maturing teleomorphic stromata, X 2. 19. Culture with conidium-bearing stromata, X 1.

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NEW OR INTERESTING SPECIES OF THE GENUS MNIOPETALUM FROM THE EASTERN HIMALAYAS

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摘 要

本文討論了傘菌目、掛鐘菌科、蘚瓣菌屬的六個種，有三種見於東喜馬拉雅地區，其中兩新種是小蘚瓣菌 *Mniopetalum miniatum* Zang 和扇狀蘚瓣菌 *M. flabelliforme* Zang . 模式標本均藏於中國科學院昆明植物研究所隱花植物標本館.

Summary

Six species of genus *Mniopetalum*, Cyphellaceae, Agaricales are discussed. Three species are reprted from eastern Himalayas, among them two new species, *Mniopetalum miniatum* Zang, and *Mniopetalum flabelliforme* Zang.

Key words: *Mniopetalum*. Eastern Himalayas.

In continuation of several mycological trips (1975-1976) to the Eastern Himalayas of Tibet, a third expedition (1981-1982) to Motou, Tibet was organized by Academia Sinica. This paper is based on the results of studies of a part of the materials collected on these cryptogamic expeditions. It is an attempt to predict the eventual range of 3 species of genus *Mniopetalum* from the Eastern Himalayas, among them two new species, *Mniopetalum miniatum* Zang and *Mniopetalum flabelliforme* Zang.

The procedure has been to compare maps showing the present known distribution range of each species of Mniopetalum with those of the distribution of the major moss-hosts in this paper.

All new collections examined are deposited in the Herbarium of Cryptogams, Kunming Institute of Botany, Academia Sinica (HKAS).

Mniopetalum Donk et Singer
in Persoonia 2(3): 332. 1962.

Mniopetalum Donk & Singer in Singer, Agar., 2nd Ed., 328. 1962 (lacking Latin description).

Fruit-body scattered or crowded, of small size on a white cobwebby mycelium. Pileus cupulate, descoid to shield-shaped or flabelliform, thin-membranous with somewhat waxy, plane or incurved margin, which is finally usually wavy,but may become lobed and crisped; outside smooth or subtomentose-silky, white, whitish yellow or pale cream coloured, but entirely without pigment. Hymenium somewhat thickening, hymenial surface smooth, but sometimes with veins which may become lamellae, white, eventually cream coloured. Hyphae thin-walled, equal, smooth, filamentous. Clamp connections present. Basidia clavate, with 4 sterigmata, 4-spored. Basidiospores hyaline, smooth, subglobose, inamyloid, thin-walled. Cystidia none or sometimes with hymenial hyphal projections. Sessile or stipe sometimes present, short and differentiated, somewhat villous or sucker-like at the base, attached to living Musci and Hepaticae.

Type species: Mniopetalum globisporum Donk.

The known distribution pattern of this genus is a bit irregular but it appears to be well scattered from the temperate regions and mountains of Europe (Singer, 1962). Horak (1980) added an important record to the generic distribution pattern when he reported that Mniopetalum distinctum Horak is confined to the Sikkim, Himalayas.It should eventually be found to occur also at least in the eastern Himalayas and adjacent areas of China (Zang & su, 1985).

Key to the species known from E. Himalayas and adjacent areas of China

1. The fungal distribution pattern northern temperature limited. On living acrocarpous mosses, especially on Mnium hornum Hedw. or Mnium thomsonii Schimp. 2

1. The fungal distribution pattern tropical or Himalayan limited. On pleurocarpous mosses or liverworts.........3

  2. Hymenium remaining smooth, without any tendency to form folds or gills....5. Mniopetalum globisporum Donk

  2. Hymenium not smooth, usually showing tendency to form folds or gills..............1. Mniopetalum bryophilum (Pers : Fr.) Donk

3. Fruit body of small size. Pileus up to 0.2-0.3 mm diam. On the leaf-surface of Homaliodendron montagneanum (C. Muell.) Fleisch. ....4. Mniopetalum miniatum Zang

3. Fruit body of small to medium size. Pileus over 0.6 cm diameter. On the gametophyte of bryophytes...........4

  4. Pileus 4-25 mm diameter. Basidiospores 4.5-6 X 3-4 µm Cystidia absent. On acrocarpous mosses.................................... 2. Mniopetalum distinctum Horak

  4. Pileus 0.6-1 cm diameter. Basidiospores 7-10 × 5-6 µm. Hymenium sometimes with hymenial hyphae projections. On Plagiochila belangeriana Lindenb. .... 3. Mniopetalum flabelliforme Zang

1. Mniopetalum bryophilum (Pers. : Fr.) Donk, in Persoonia 2 (3): 336. 1962; ——— Agaricus bryophilus Pers., Obs. Mycol. 1: 8. 1796; ——— Merulius bryophilus (Pers.) Pers., Syn. Method. Fung. 495. 1801; ——— Leptoglossum bryophilum (Pers. : Fr.) Ricken, Blätterp. 6. 1910.

Yunnan: Lijiang, Yulung Mts. 3100 m. alt. On living mosses, especially on Mnium thomsonii Schimp.

The fungus may be somewhat northern temperature and Himalayan alpine region limited, the fungal hosts, Mnium hornum Hedw., and Mnium thomsonii Schimp., have a fairly wide range in the boreal to temperate zones in Europe, eastern North America and eastern Asia (Koponen, 1973; Li

& Zang, 1979). Consideration of the known distribution of the fungus and of its *Mnium* - host indicates that the fungus will probably be found in western China and northern China. (Fig. 9)

2. *Mniopetalum distinctum* Horak, Sydowia 33: 100. 1980.

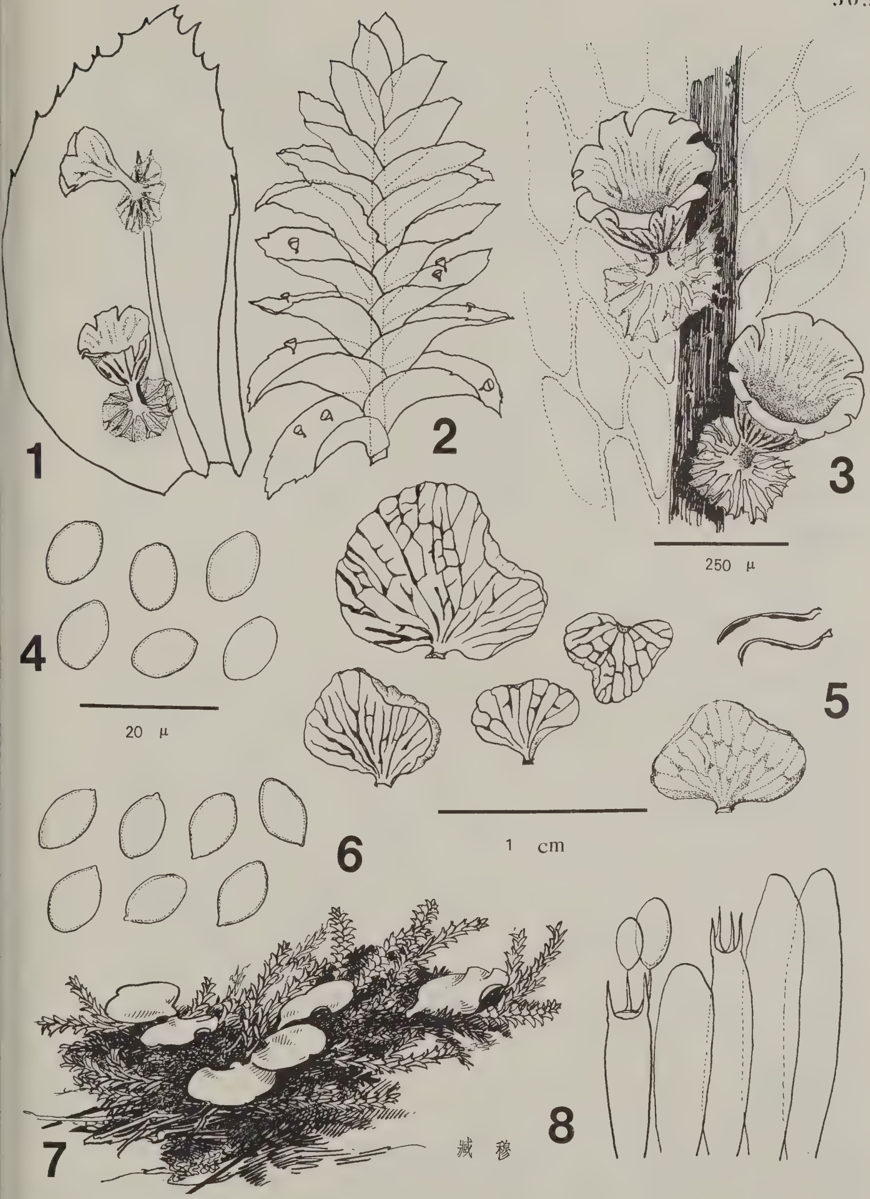
India: Sikkim, upper Rangit, Zompuk, N of Yoksam, 2100 m. alt. On living mosses along creek. 5 XI 1979. E. Horak (1980).

3. *Mniopetalum flabelliforme* Zang, sp. nov.
(Figs. 5-8)

Pileus 0.6-1 cm, cupuliformis dein flabelliformis, albus vel cremeus, glabrous, haud gelatinosus, membranaceus, laevis vel obsure translucido-striatus. Lamellae venosae vel reticulatae, subdecurrentes, plicae saepe dichotomiter ramosae, albidae vel flavido-albidae. Stipes 1-2 mm longus, 2-3 mm crassus, lateraliter insertus, cylindricus, clavatus vel ad basim leviter incrassatus. Pileo concolor. Basidiosporae 7-10 x 5-6 µm. ovatae, hyalinae, inamyloideae. Basidia clavata, 7.5-10 X 15-25 µm. 4-sporigera. Hyphae hymenii projectis clavatis praeditae, hyphae fibulatae. Odor et sapor subnullus.

Habitat: Ad ramos *Plagiochilae belangerianae* Lindb. Xizang (Tibet): Motou. In *Pinetis griffithii* McCl. 1900 m. alt. 24 V 1983. Su Yong-ge 3984 (HKAS 16402, Typus).

Pileus 0.6-1 cm, spathuloid, cupulate or fan-shaped, whitish to cream, dry, smooth, membranous, not gelatinous, often translucently striate, veil remnants absent. Lamellae venose to reticulately nerved, often dichotomously forked towards margin, subdecurrent, whitish to whitish yellow. Stipe 1-2 mm long, 2-3 mm broad, always lateral, cylindric, equal or declined towards base, concolorous with pileus, glabrous, solid, dry. Context whitish, nor gelatinous. Basidiospores 7-10 X 5-6 µm,



Figs 1-8. Mniopetalum miniatum Zang (HKAS 15264): 1-3. Fruit bodies on leaves of Homaliodendron. 4. Basidiospores. Mniopetalum flabelliforme Zang (HKAS 16402): 5. Fruit bodies. 6. Basidiospores. 7. Habit sketch (del Zheng Xiaolian). 8. Basidia and hymenial hyphal projections.

ovoid, hyaline, smooth, inamyloid. Basidio 15-25 X 7.5 -10 µm, clavate, 4-spored. Hymenium sometimes with hymenial hyphal projections. Clamp connections numerous. Odour and taste not distinctive.

On living liverworts, especially on branches of *Plagiochila belangeriana* Lindenb.

Xizang (Tibet): Motou. In *Pinus griffithii* McClelland 1900 m. alt. On branches of *Plangiochila belangeriana* Lindb. 24 V 1983. Su Yong-ge 3984 (HKAS 16402, Type).

Mniopetalum flabelliforme Zang apparently is closely related to *Mniopetalum distinctum* Horak, differing, however, by the larger carpophores and spore size, the stipes usually declined towards the base and never attenuated.

4. Mniopetalum miniatum Zang, sp.nov.

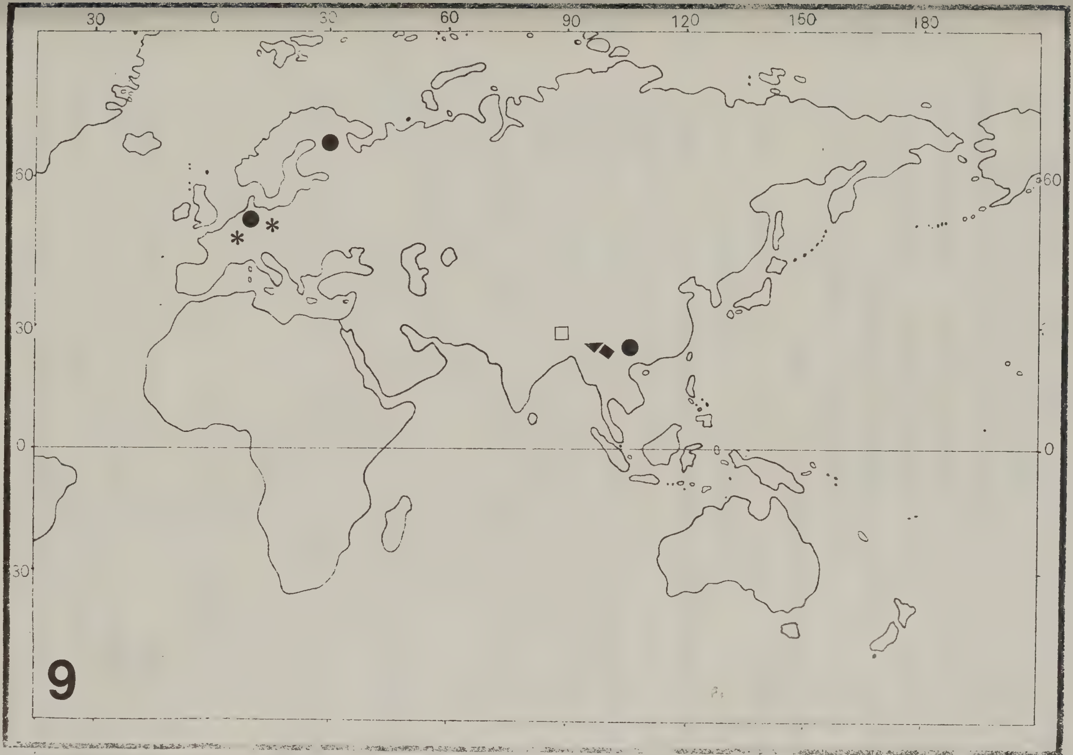
(Figs. 1-4)

Sporophorum miniatum, solitarium, cupulatum, 300-500 um longum, stipitatum, demum disciformi-applanatum, ca. 0.2 - 0.3 mm diam., membranaceum, marginem integrum vel obtritum, album vel cremeum. Lamellae venosae vel nullae, plicae saepe dichotomiter ramosae, decurrentes, albidae vel cremeo albidae. Stipes 90-100 µm longus, 20-40 µm crassus, in centro, aequalis vel ad basim leviter incrassatus, prominentiam rhizomorphum formans, pileo concolor. Basidiosporae 7-10 x 5.5-6 µm, ovatae, hyalinae, inamyloideae. Cystidia nulla. Hyphae fibulatae.

Habitat: In sylvis frondosis, ad muscos vivos, in foliis *Homaliodendronis montagneani* (C. Muell.) Fl.

Xizang (Tibet): Motou, 1200 m. alt. 1 VII 1981. Su Yong-ge 4939 (HKAS 15264, Typus).

Fruit-body usually small, scattered on a whitish rhizoid mycelium, pileus cup or disk shaped, up to 0.2-0.3 mm diameter, thin membranous, margin entire when young, but slightly incurved, finally usually wavy and becom-


9
30
0
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60
90
120
150
180
60
30
0
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0

Fig. 9. Distribution of Mniopetalum. ● Mniopetalum bryophilum (Pers. : Fr.) Donk; □ Mniopetalum distinctum Horak; ■ Mniopetalum flabelliforme Zang; ▼ Mniopetalum miniatum Zang; ✱ Mniopetalum globisporum Donk.

ing lobed or crisped at maturity. Lamellae venose to plicate, often dichotomously forked towards margin, decurrent, whitish to cream coloured, occasionally hymenium smooth. Stipe 90-100 µm long. 20-40 um broad, always central, equal and straight, with numerous rhizoids attached on the ventral surface of mosses leaves, concolorous with pileus, glabrous, solid. Basidiospores 7-10 X 5.5-6 µm, ovoid, hyaline, smooth, inamyloid. Cystidia absent. Clamp connections numerous.

Hab. On living mosses, especially on the leaves of *Homaliodendron montagneanum* (C. Muell.) Fl.

Xizang (Tibet): Motou. In broad-leaves woods. 1200 m. alt. 1 VII 1981. Su Yong-ge 4939 (HKAS 15264, Type).

This resembles *Mniopetalum bryophilum* (Pers. : Fr.) Donk, being similar in the colour of the basidiocarps and in growing on living mosses, but differs in the smaller overall size, the length of basidiocarp usually below 0.5 mm. There are also a clear differences in habitat and distribution patterns. *Mniopetalum bryophilum* (Pers. : Fr.) Donk is distributed in the Eurasian temperate region, and grows on living *Mnium hornum* Hedw. or *Mnium thomsonii* Schimp., but *Mniopetalum miniatum* Zang occurs in the tropical region of the eastern Himalayas and grows on the living leaves of *Homaliodendron montagneanum* (C. Muell.) Fl.

5. *Mniopetalum globisporum* Donk, in Persoonia 2(3): 332. 1962.

This is a rare species known from the Netherlands, Germany and presumably throughout western Europe. It occurs usually on the genus *Mnium*. The fungus should eventually be found in North China and West China, where its hosts are distributed (Fig. 9).

Extralimital species

Mniopetalum bisporum Singer, Agar., 2nd Ed. 329. 1962.

This species recorded from the temperate regions and mountains of Europe. It has been described by R. Singer (1962), until now with certainly known it does not found from Asia.

Acknowledgments

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A NEW LOBATE SPECIES OF THE LICHEN GENUS LECANORA (ASCOMYCOTINA, LECANORACEAE)

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SUMMARY

A conspicuous, squamulose-lobate lichen, resembling some morphotypes of *Rhizoplaca chrysoleuca*, was found to be widespread in the Great Lakes - St. Lawrence Forest region of southern Canada and the adjacent United States, and in parts of the blue-stem prairies, growing on granitic rocks. It is described here as a new species: *Lecanora opiniconensis* Brodo.

On a few of the small rocky islands in Lake Opinicon, one of the larger bodies of water in the Rideau Lakes system of southern Ontario, a yellowish, lobate lichen was found mixed with *Rhizoplaca chrysoleuca* s. lato on the rock faces above the water. One of these islands was used as the site of a population study of saxicolous lichens (Woolhouse et al., 1985), and the identity of the species became critical. The lichen was compared with other *Rhizoplaca* and *Lecanora* species, and it became evident that it was undescribed. Since its first discovery over ten years ago, it has been collected in several other areas of Pre-Cambrian Canadian Shield in Ontario and Quebec, and from a study of herbarium specimens, is now known to be much more widespread (Fig. 1). The name "*opiniconensis*," although validated here, has already appeared twice in print: as a species of *Lecanora* (Brodo, 1981), and in *Rhizoplaca* (Woolhouse et al., 1985).

Lecanora opiniconensis Brodo, sp. nov. (Figs. 2-5)

Thallus viridi-flavescens, glabratus, subnitidus, primum squamulosus areolibus marginalibus distincte effiguratis, demum tumulos hemisphaericos, ca. 3-15 mm latos efficiens. *Apothecia* sesselia, basi ± constricta, marginibus pallide viridi-flavescentibus demum irregulariter crenati-lobatis, et discis pallide flavidis ad pallide aurantiacis. *Sporae* ellipsoideae ad ovatae, (8.5-)9.5-11.5 x 5.5-7.0(-7.5) µm. Continet acidum usnicum, acidum placodialicum et substantias inexplicatas "Lop-1" et "Lop-2."

Typus: Canada. Ontario: Leeds County: Chaffey's Lock. 44°34'N, 76°20'W. Snake Island in Lake Opinicon; on S-facing granitic rocks, 1.0-1.5 m above water, 2 Feb. 1985. Brodo 25117 (holotypus - CANL; isotypi - US, ASU, H, GRAZ).

Thallus greenish yellow to strong yellow (no. 102-105, or 84* at lobe tips), "waxy" in appearance, smooth and fairly shiny; at first composed of scattered squamules 0.7-1.5 mm in diameter, soon becoming imbricate, often building into distinctly stipitate hemispherical mounds ca. 3-15 mm in diameter (Fig. 3), finally becoming marginally lobed, with lobes up to 1.5 mm across and 1.5 mm long, slightly to strongly convex, sometimes forming circular patches up to 30 mm in diameter (Fig. 2); thallus margin definite or indefinite; soredia and isidia absent; prothallus absent; undersurface of lobes pale yellowish white to pale orange-yellow (no. 92-73), or sometimes yellow (no. 83-84) at edge, to greyish brown (no. 81) or blackish at center; upper cortex of thallus consisting of decomposed hyphae with very small cells (a kind of "scleroplectenchyma"), the cellular layer ca. 20 µm thick, subtending a 7-9 µm thick more-or-less clear necrotic layer, with both the above layers containing abundant, short, yellow crystals (probably usnic acid) (Fig. 4); algal layer very distinct, thick, with large, Trebouxioid algal cells often arranged in vertical columns; medulla lax, composed of slender, unornamented hyphae (2.5-3.5 µm thick); lower cortex prosoplectenchymatous, with easily distinguishable hyphae, lightly pigmented at surface (Fig. 5).

Apothecia lecanorine, broadly attached, becoming constricted in age and sometimes rather flexuose, 0.7-1.3(-2.0) mm in diameter; disks epruinose, light to medium orange-yellow (no. 70-71) when dry, more greenish when wet; margin almost the same color as the disk (no. 70) or slightly more yellowish, smooth, even to crenulate, moderately thick but becoming thin in older apothecia, and excluded in some.

Epihymenium brownish-yellow (no. 84-85), heavily inspersed with fine, KOH soluble, HNO_3 insoluble granules; hymenium 50-60 µm high, hyaline; paraphyses septate, simple to branched once or twice at tips, barely capitate; hypothecium prosoplectenchymatous, hyaline, 55-100 µm thick at the center; algal layer distinct, much as in thallus; small angular crystals partly filling the medulla, KOH soluble, HNO_3 insoluble (unlike oxalate crystals such as are found in the Lecanora subfusca group). Spores (8.5-)9.5-11.5 x 5.5-7.0(-7.5) µm, rather variable in shape from ellipsoid to egg-shaped or even somewhat cylindrical, all within a single apothecium.

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* Color designations with code numbers refer to Kelly (1965).

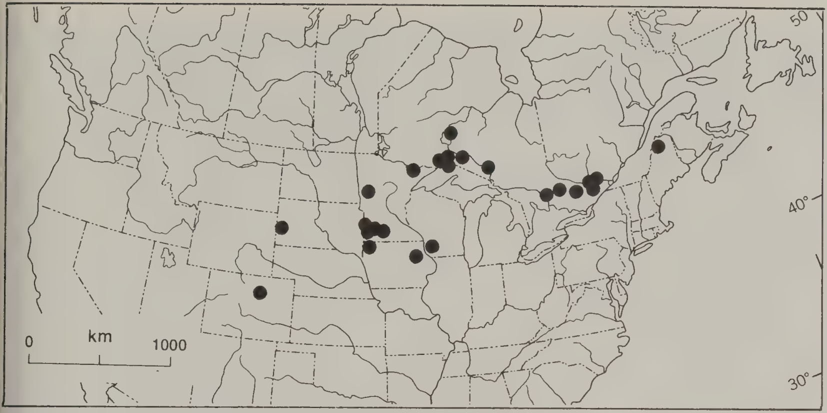


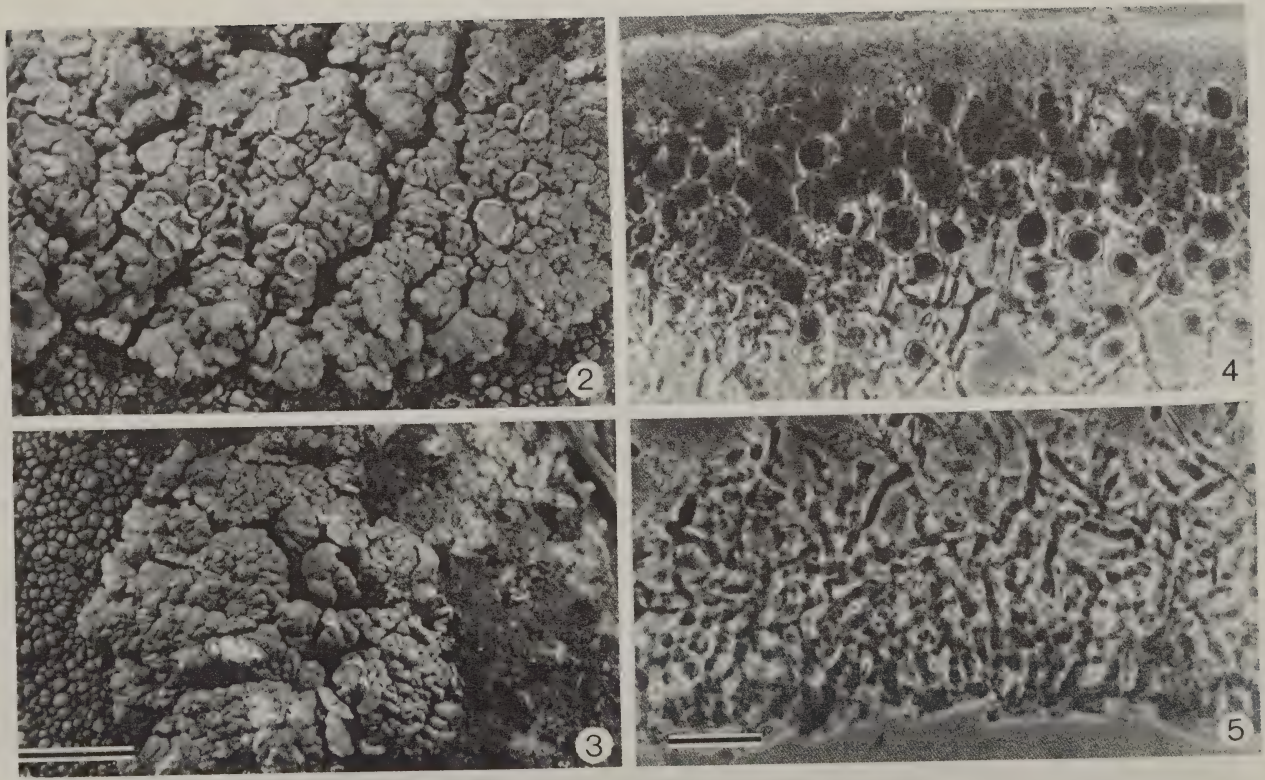
Fig. 1. The known distribution of Lecanora opiniconensis.

Chemistry: Cortex C-, K-, KC+ yellow, PD-; medulla C+ yellow, K+ yellow, KC+ orange-yellow to pink-orange; PD- or + yellow, rarely with a region just above the lower cortex turning PD+ orange (due to an accessory pigment). Contains (by TLC): usnic and placodialic acids, several unidentified triterpenoids (two of which are fairly constant), and sometimes an orange pigment in the thallus. In addition, there are two near-constant unknown compounds that can be called Lop-1 and Lop-2. Their characteristics, together with those of the other compounds found in the new species, are given in Table 1.

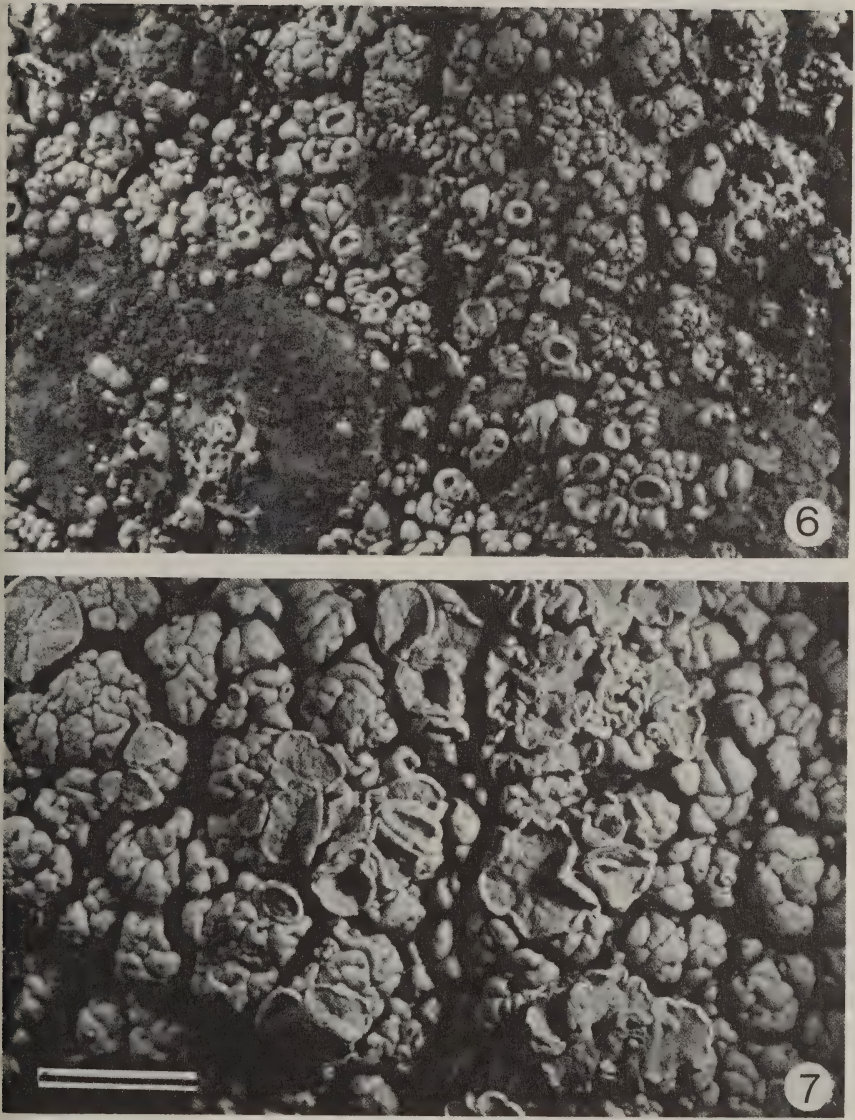
Habitat: Growing on non-calcareous, generally granitic rocks, in full sun. In the Canadian Shield region, it is most often on lake or stream shores just above the high water mark, but it is apparently frequent on exposed granitic boulders in open grasslands as well. It is commonly associated with Rhizoplaca chrysoleuca s. lato, Rhizocarpon grande (Floerke ex Flot.) Arn., Aspicilia cinerea (L.) Koerber, A. verrucigera Hue, Acarospora fuscata (Nyl.) Arn., Xanthoparmelia cumberlandia (Gyeln.) Hale, and X. plittii (Gyeln.) Hale.

Distribution: Following the Pre-Cambrian Canadian Shield from Minnesota through the Great Lakes region to northern Maine, and in the northern blue-stem prairies of Minnesota, Iowa and Wisconsin, with disjunct occurrences in the Black Hills of South Dakota and in the southern Rocky Mountains (Fig. 1).

Specimens examined: Canada. Ontario. Thunder Bay District: Thunder Bay, Garton 5467 (CANL); Turtle Head on Pie Island, Garton 6089 (CANL); Slate Islands, Wetmore 28714, 29679 (CANL); Fort William, at base of Mt. McKay, Brodo 13575B (CANL); N. Ombabika Bay, Lake Nipigon, Garton 22268 (CANL). Algoma District: Lake Superior Provincial Park, Denison 456 (CANL). Parry Sound District: Parry



Figs. 2-4. *Lecanora opiniconensis*, holotype (*Brodo 25117*). - 2,3. Thalli showing lobate margins and hemispherical mounds. Scale = 5 mm. - 4. Upper cortex of thallus. -5. Lower cortex of thallus. Scale (figs. 4-5) = 25 um.



Figs. 5-6. Rhizoplaca chrysoleuca, eastern North American morphotypes. Scale = 5 mm for both. - 5. Quebec, Wong 3259 (CANL). - 6. Ontario, Larson, s.n. (CANL 6285).

Sound, Island in Georgian Bay, *Cain 26672* (CANL). Renfrew County: Algonquin Provincial Park, Barron River Gorge, *Dickson 154* (CANL); Calabogie, *Brodo 20277* (CANL). Leeds County: Chaffey's Locks, Lake Opinicon, *Brodo 23432B*, *23543*, *25117* (type) (CANL). Quebec. Gatineau County: Gatineau Park, Luskville, *Brodo 21015* (CANL), Lac Lapeche, *Brodo 21036A* (CANL); Lac St-Germain, Poltimore, *Brodo 24983* (CANL).

United States. Colorado. Boulder County: St. Vrain Canyon 9 miles SW of Lyons, *W. Weber* & *Klockenbrink L-63350* (MIN). Iowa. Fayette County: ..., *Fink 1894* (MIN); Lyon County: "2 mi. N.W. .. near White's farm", *Shimek* [fide Wetmore, in lit.], s.n. (MIN). Maine. Aroostook County: Umsaskis Lake, *Selva 990*,*987* (SELVA). Michigan. Keweenaw County: Isle Royale Nat. Park, *Wetmore 47222* (CANL). Minnesota. Brown County: New Ulm, *Fink 266* (MIN); Otter Tail County: Boltte Lake, *Fink 46* (MIN); Redwood County: North Redwood, *Fink 361* (MIN); Pipestone County: Pipestone, *Fink 599*, *642* (MIN); St. Louis County: Voyageurs National Park, Rainy Lake, *Wetmore 34532*, Namakan Lake, *Wetmore 35014* (CANL); Yellow Medicine County: Granite Falls, *Tucker 12346*, *Fink 409* (MIN). South Dakota. Pennington County: Rapid City, Bogus Jim Creek, *Wetmore 8760* (CANL). Wisconsin. Iowa County: (NW of Dodgeville), *Cochrane 5601* (CANL).

DISCUSSION

The generic boundaries between the various groups of placoid *Lecanorae* are still not clear. The species being described here as a new *Lecanora* resembles some species of *Rhizoplaca* and, indeed, I considered placing it in *Rhizoplaca* because of its similarity to morphotypes of *R. chrysoleuca* growing in the same region (see comments below), and because it contains placodialic acid. The cortical structure of the thallus, however, (proso- rather than paraplectenchymatous lower cortex), dense rather than lax medulla, and distinctly placoid rather than umbilicate habit made it difficult for me to justify placing it in *Rhizoplaca*. Until a thorough review is made of the relationships between *Rhizoplaca*, the *Lecanora muralis* group, and other lobate *Lecanorae*, I thought it best to classify it within *Lecanora* in the broad sense.

The genus *Rhizoplaca* has only been segregated from *Lecanora* in recent years since the publication of a chemosystematic revision by Leukert et al. (1976) followed by their summary and key (in Poelt & Vězda, 1977). In temperate, eastern North America, the genus was thought to be represented only by a population referred to by most authors as *R. chrysoleuca* (Sm.) Zopf (Syn. *Lecanora rubina* (Vill.) Ach.). The squamulose-crustose thallus of this population (Figs. 6-7), however, does not correspond exactly to the "typical" morphotype with peltate to umbilicate thalli commonly found in North America from the Lake Superior region westward, and elsewhere. In fact, the taxonomy of at least the North American populations of R. chrysoleuca requires a reevaluation (see the comments below regarding R. subdiscrepans).

Lecanora opiniconensis is immediately distinguished by its non-pruinose, relatively shiny, yellowish thallus and apothecial disks, in comparison with the dull, grey-green thallus and pruinose, pinkish-orange disks of Rhizoplaca chrysoleuca. Rhizoplaca melanophthalma (DC. in Lam. & DC.) Leukert & Poelt differs in being very dark below (almost a bluish-black), and in having greenish-black, pruinose apothecial disks. In North America, it is strictly northern and western, not occurring in eastern temperate regions.

The species described here comes close to R. subdiscrepans (Nyl.) R. Sant. in overall appearance, but the latter is barely distinguishable from R. chrysoleuca in thallus and apothecial colour and texture, essentially representing a squamulose-crustose morphotype of that species. Like Lecanora opiniconensis, however, Rhizoplaca subdiscrepens contains placodialic acid. The eastern squamulose-crustose population of R. chrysoleuca closely resembles European specimens of R. subdiscrepans seen from CANL but contains pseudoplacodialic acid rather than placodialic acid. Umbilicate morphotypes of R. chrysoleuca can contain placodialic or pseudoplacodialic acids, or lack both of them (Leukert et al., 1976). All three chemical races, plus one with psoromic acid, also mentioned in Leukert et al. (1976), occur in North America.

Three western species recently transferred to Rhizoplaca (R. glaucophana (Nyl. ex Hasse) W.A. Weber, R. haydenii (Tuck.) W.A. Weber, and R. marginalis (Hasse) W.A. Weber) (Weber, 1979) are morphologically and chemically very different from the new species.

In colour and in certain growth form characteristics, Lecanora opiniconensis resembles some specimens of L. muralis (Schreb.) Rabenh. and L. polytropa (Hoffm.) Rabenh., but both these species contain zeorin in addition to usnic acid, and L. polytropa has been reported to contain rangiformic acid (Huneck, 1966). These species differ morphologically as well: L. muralis often has a lobate apothecial margin, and the thalline lobes are longer, narrower, edged in white, and are often pruinose; L. polytropa is usually almost athalline.

Chemistry is very helpful in characterizing L. opiniconensis. The thallus contains two essentially constant unidentified substances, called here "Lop-1" and "Lop-2" (see Table 1). (In some thalli, the unknowns are difficult to demonstrate and may be absent.) There are also several unidentified triterpenoid substances which often occur as traces and may or may not be constant. Zeorin, however, is absent. The orange pigment found in some thalli does not seem to be of any taxonomic importance.

R_F classes			Compound	Comparative R_F's			UV (LW) before acid	Colour after acid charring
A	B	C		A 54,79	B 50,85	C 18,63		
3(-4)	5-6	5	Lop-1	47	67	24		grey-brown (faint) [#60-63]
4-5	5-6	4-5	Triterpene A	57	61	19		grey-brown (faint) [#60-63*]
?	6	6	Triterpene B	?	71	43		dull greyish-reddish purple [#245-261]
6	5-6	6	Pseudoplacodialic	78	64	50	quench	med. grey - greenish grey [#265-155]
6	6	6	Placodialic	77	75	55	quench	dark greyish yellowish brown [#81]
6	6	6	Usnic	78	81	56	quench	light to dark greenish grey [#154-149-155]
7	6	7	Lop-2	79	80	63	yellowish	yellowish brown [#76]

Table 1. Secondary Metabolic Substances in *Lecanora opiniconensis* and eastern North American populations of *Rhizoplaca chrysoleuca*. The numbers separated by a comma under A,B,C in the "Comparative R_F's" column are R_F's of norstictic acid and atranorin in solvents A, B, and C (Culberson, 1972), respectively. The numbers in that column are the R_F's of the compounds themselves. Numbers in the "Colour after acid" column refer to colours found in Kelly (1965).

Lecanora opiniconensis is often not abundantly fertile, and sterile thalli are common. On the other hand, it is competitively vigorous, often overgrowing other lichens on the same surface. Its frequent association with lakeshore rocks may indicate a requirement for periodic splashing or inunudation in the northern part of its range, but it is clearly a member of the fully insolated, acid rock community in other respects.

Except for the prairie localities, the distribution of *Lecanora opiniconensis* is remarkably similar to that of the recently described *L. fuliginosa* Brodo (Brodo, 1984) even to the "disjunct" occurrences of both in Colorado, the Black Hills of South Dakota and northern Maine, although *L. fuliginosa* is known to be more widely distributed to the north. This impression may be due to the relatively small number of samples examined in this study. The species will probably be collected in other areas of the Canadian Shield to the north and west.

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INTERCOMPATIBILITY AND THE SPECIES CONCEPT IN THE SAPROBIC BASIDIOMYCOTINA.

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RESUME

Emploi des croisements entre haplontes dans la délimitation des espèces biologiques chez les Basidiomycètes, notamment lignicoles; essai d'interprétation des résultats; précautions à prendre, spécialement entre récoltes allopatriques.

The systematics of the major taxa of fungi has not kept pace with similar studies of the major groups of flowering plants. There are many reasons for the relatively slow progress of fungal systematics. First, the somatic thalli of many fungi develop within the soil, decaying wood, manure, or other nutrient sources and can only be properly observed and studied in pure culture. Second, the fruiting bodies of many fungal species are ephemeral and appear at irregular intervals; therefore, the reproductive structures of some species have been collected only once or twice and, even then, very often from widely separated geographical localities. Also fungal nuclei are comparatively small and difficult to study; therefore, chromosome numbers have been documented for a very small number of species. Thus, very few cytotaxonomic studies of the fungi have been productive. Further the morphological differences between a number of fungal taxa are often minute and difficult to discern. Contributing to the slow progress of fungal systematics, in addition to factors inherent in the organisms themselves, is the fact the number of individuals studying fungal systematics is considerably less than the number of flowering plant taxonomists. For these and other reasons, fungal taxonomy is in relatively simplistic state, as compared to flowering plant taxonomy, even in well studied regions as Europe and North America. In many tropical and equatorial regions, many taxa of fungi are very imperfectly known.

In this paper, I wish to demonstrate the advantages of the utilization of mating tests in taxonomic studies in the Basidiomycotina, especially of the lignicolous species which are relatively easy to culture. Shortly after the initial studies of the tetrapolar (i.e. bifactorial) compatibility system in the Basidiomycotina by Bensaude (1918) and Kniep (1920), Vandendries (1923) proposed that mating tests would be useful in defining species. He wrote:" Si des haplontes de deux carpophores sauvages sont toujours et indéfiniment fertiles entre eux, ces deux carpophores appartiennent à la même espèce". Acceptance of the concept of biological species based on intercollection matings has developped slowly. Today, however, intercompatibility tests are being more widely used, and it is appropriate to discuss some of the major results of mating tests and to stress several of the possible errors of interpretation. I would also welcome comments relating to my interpretations of mating tests from systematists of other groups of organisms.

The Basidiomycotina, especially the wood decaying species, are relatively easy to study for the following reasons:

1- The basidiospores of many species germinating readily, and the monokaryotic hyphae can be maintained indefinitely in pure culture.

2- Since gametangia are unknown among the Homobasidiomycetes, matings can be carried out immediately following spore germination or years after the initial isolation, i.e., it is unnecessary to induce a particular stage of ontogeny before plasmogamy will take place.

3- There is no evidence of ethological barriers, as in animals.

4- Since most species are heterothallic with multiple alleles at one or two loci, the percentage of intercompatibility isolates from the natural populations approaches IOO %.

5- Clamp formation in many species is an indication of succesful plasmogamy and of the establishment of a stable dikaryon.

6- The prolonged dikaryotic phase appears to be an important barrier to hybridization among the Basidiomycotina

While the presence of clamp connections and dikaryons in mated colonies is not a sign of absolute interfertility, it is certainly an indication of close intercompatibility. It is necessary to establish that karyogamy meiosis, basidiospore formation, and basidiospore germination take place and that the monokaryotic progeny are viable and normal before it can be proven that the mated strains are interfertile; however, the difficulty of inducing sporulation in culture of most species of the Basidio mycotina presently precludes the establishment of proof of fertility of many mating tests. Nevertheless, the presence of the dikaryon in a common protoplast and repetitive conjugate nuclear divisions of these nuclei to form an extensive thallus certainly suggest a close genetical relationship. In bifactorial species the formation of clamp con nections at the margins of the mated monokaryotic isolates requires the complementary action of two A factors; nuclear migration between the mated strains and fusion of the clamp cell with the subterminal hyphal segment are controlled by two B factors. The combined effects of the A and B factors results in clamps at the margins of the mated colonies within 2 to 4 weeks following contact. In matings between isolates of the same species from different area, IOO % of the crosses result in the formation of clamps because of the multiple allelic nature of the A and B factors; rare negative matings result from duplicate A factors, and false clamps can be attribued to duplicate B factors.

One of the major problems in utilizing these techniques in speciation studies is the difficulty of inducing basidiocarp formation in the laboratory. Since relatively few species sporulate readily in culture, it is necessary to rely on observations of the nuclear state of the mated thalli and the presence or absence of clamps. For this reason it is preferable to refer to crosses resulting in a stable dikaryon as indicating "intercompati-

		P. vespillonea						*P. involuta*			*P. gillesii*			
		5429	5557	6501	6511	6733	6854	6074	6035	6503	6698	6827	6906	6920
P. vespillonea	5429		+	+		+	+	—	—	—	—	—	—	—
	5557	+		+			+		—		—		—	
	6501	+	+		+	+	+	—	—	—	—	—	—	—
	6511			+					—	—			—	—
	6733	+		+			+			—		—	—	—
	6854	+	+	+		+			—	—		—	—	—
P. involuta	6074	—		—					+	+	—			—
	6035	—	—	—	—		—	+		+	—	—	—	—
	6503	—		—	—	—	—	+	+		—	—	—	—
P. gillesii	6698	—	—	—				—	—	—		+	+	+
	6827	—		—		—	—		—	—	+		+	+
	6906	—	—	—	—	—	—		—	—	+	+		+
	6920	—		—	—	—	—	—	—	—	+	+	+	

Fig.1 : Matings of African strains of *Podoscypha involuta* sensu lato. Based on these data, it is necessary to recognize three species (Boidin and Lanquetin, 1973).

bility" or "interincompatibility" (Boidin and Lanquetin, 1977) between the mated strains rather then "fertility" and "infertility".

Other difficulties that are frequently encountered are as follows:

a- The dikaryotic hyphae of some species do not form clamps. In such cases it is necessary to employ nuclear stains or to utilize phase contrast optics to determine the nuclear stage of the hyphal segments.

b- Some species form multinucleate mycelium. With such species an effort must be made to induce basidiocarp formation as dikaryons often appear only in the subhymenium or in the basidioles.

c- A few species are homothallic; therefore, single spore isolates will form clamps, dikaryotic hyphae, and fertile basidiocarp.

d- It has not been possible, with our present techniques, to culture many taxa, especially terricolous species such as those of Inocybe, Hydnellum, etc...

The indices with useful informations for intercompatibility tests in Basidiomycotina have been published (Boidin and Lanquetin 1984a, 1984b, 1984c; Capellano 1985). Indices concerning the poroid Aphyllophorales and the Agaricales are presently being prepared.

	DICHOSTEREUM										
	durum	sordulentum			ramulosum		rhodosporum	pallescens		peniophoroides	
	FRANCE	GEORGIE	LOUISIANE	ARGENTINE	GABON	COTE d'IVOIRE	AUSTRALIE	MARYLAND	NEW-YORK	GUADELOUPE 1	GUADELOUPE 2
durum	+	(-)	(-)	(-)	-	-	-	-	-	-	-
sordulentum	(-)	+	+	+	-	-	-	-	-	-	-
	(-)	+	+	+	-	-	-	-	-	-	-
	(-)	+	+	+	-	-	-	-	-	-	-
ramulosum	-	-	-	-	+	+	-	-	-	-	-
	-	-	-	-	+	+	-	-	-	-	-
rhodosporum	-	-	-	-	-	-	+	-	-	-	-
pallescens	-	-	-	-	-	-	-	+	+	-	-
	-	-	-	-	-	-	-	+	+	-	-
peniophoroides	-	-	-	-	-	-	-	-	-	+	+
	-	-	-	-	-	-	-	-	-	+	+

Fig. 2 : Compatibilities and incompatibilities between species of the genus *Dichostereum* . (-) = few clamped hybrid mycelia.

While the scarce applications of intercompatibility tests during the past 60 years have given, in most cases, either completely positive or completely negative results, a few studies have yielded intermediate results. My interpretattions of these will are discussed below.

It has been possible to utilize compatibility tests in a number of ways as follows:

a- There are numerous examples of compatibility tests being used to determine if dubious species are reproductively isolated from morphologically similar species. For example, *Podoscypha involuta* (Klotzsch) Imaz. is a paleotropical species for which Reid (1965) noted 14 synonyms and described as " one of the most variable of all the stipitate stereoid fungi ". Boidin and Lanquetin (1973) detected three interincompatible groups among 13 collections from Central Africa (Fig.1). These interincompatible groups were correlated with basidiocarp color and were proposed as distinct species (Boidin and Lanquetin, 1973)

Mycologists have disagreed on the number of species to be included in the genus *Dichostereum* Pilat; however, the results of interincompatibility studies (fig.2), which are summarized above, are clear (Lanquetin, 1973 b; Lanquetin and Boidin, 1983); six interincompatible species are clearly evident. Likewise, Ginns (1985) proved the existence of 4 species of the genus *Hericium* Pers. in North America, two of them are present in Europe.

b- It has been possible to provide experimental evidence on the range of variation of various morphological characters to be expected within sympatric populations by correlating mating tests with comparative morphological studies. For example, Boidin and al. (1980) studied spore size in 15 collections of *Vararia amphithallica* Boidin, Lanquetin and Gilles, which were intercompatible. These authors found that the spore length varied from 12.52 to 17.85 µm (R= 17.85:12.52 = 1,43).(Fig.3)

c- Using intercompatibility studies it has been possible to demonstrate the complete reproductive isolation between taxa with different compatibility systems. *Vararia amphithallica* differs from *V.firma* Boidin in the possession by bisporic basidia and being tetrapolar and amphithallic; the two are interincompatible (Boidin, 1977). Lemke (1969) found that *Sistotrema brinkmannii* (Bres.) J. Erikss. was composed of groups of homothallic, unifactorial (=bipolar), and bifactorial (=tetrapolar) isolates that were intersterile. The unifactorial and homothallic isolates of *Hyphoderma setigerum* (Fr.)Donk were found to be interincompatible (Boidin and Lanquetin, 1965). Likewise, Berthier (1974) found that heterothallic isolates of *Typhula culmigena* (Mont.et Fr. in Fr.)Schroet. were not ccompatible with the amphithallic strains of this taxon. I believe that it will necessary to consider these forms that differ in the type of compatibility system and that are genetically isolated as distinct biological species.

d- Interincompatibility results are also necessary in defining cryptic, or sibling, species. Examples from the Agaricales include four sibling species of the *candolleana* group of *Psathyrella* (Galland, 1973, and Galland and al., 1979), five sibling species of *Armillaria mellea* (Fr.) Karst. in Europe (Korhonen, 1978), and ten interincompatibility groups of *Armillaria mellea* in North America (Anderson and Ullrich, 1979), and three sibling species of *Paxillus involutus* (Batsch.:Fr.)Fr. in Sweden (N.Fries, 1985). Among the Aphyllophorales, Boidin (1977) has demonstrated the existence of five sibling species within

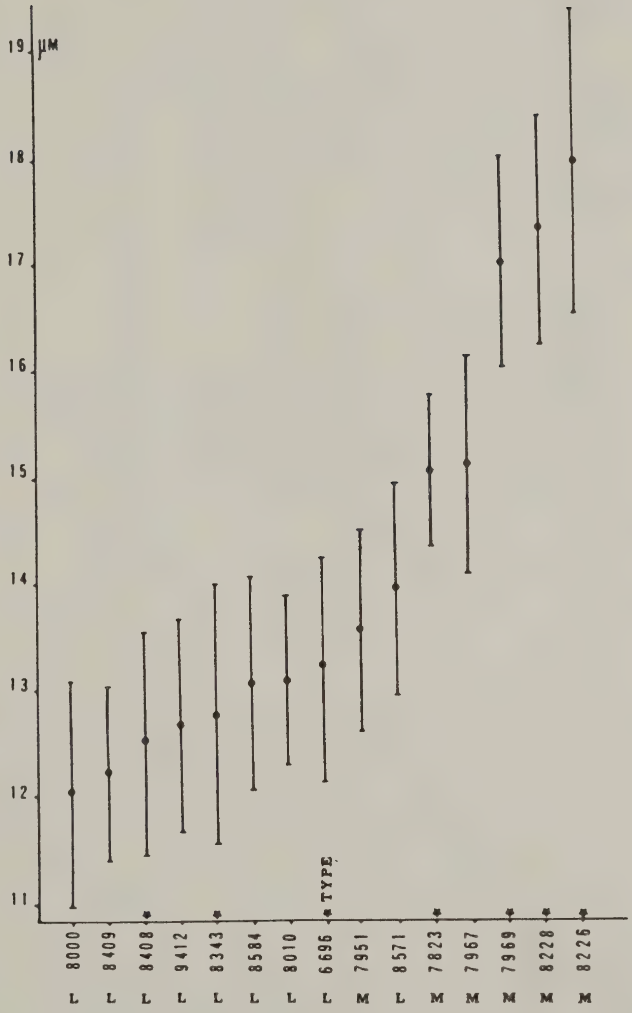


Fig.3 : The average length of basidiospores and standard deviation of specimens of *Vararia amphithallica* from Gaboon. (L=Libreville; M=Makokou; * = isolates mated). The results of the crosses of all mated monokaryons were positive (Boidin and al., 1980).

SCYTINOSTROMA	portentosum	hemidichophyticum		duriusculum			cultures reçues comme portentosum	
	FRANCE	MAROC	MAROC	MARTINIQUE	CENTRAFRIQUE	ARGENTINE	CANADA	TEXAS
portentosum	+	-	-	-	-	-	-	-
hemidichophyticum	-	+	+	-	-	-	+	-
	-	+	+	-	-	-		
duriusculum	-	-	-	+	+	+	-	+
	-	-	-	+	+	+		
	-	-	-	+	+	+		

Fig.4 : Results of crosses between the species of *Scytinostroma* with spherical basidiospores and lacking clamp connections. Three species are evident and are interincompatible; *S.hemidichophyticum* and *S.duriusculum* were previously unknown from North America (Lanquetin, 1973). *Scytinostroma portentosum (= S.aluta*, Lanquetin, 1984) is used here in the sense of European authors.

the concept of *Laxitextum bicolor* (Pers.:Fr.) Lemke. These and many others, are distinct biological species as they are genetically isolated but are essentially indistinguishable or difficult to distinguish by comparative morphology. I believe that it is desirable to follow Kiriakoff (1948) and use the term ultraspecies, abbreviated as ultsp. ,for groups of species indistinguishable morphologically but are interincompatible. Thus, if the exact biological species of a particular collection has not been determined with cultural studies, it can be designed as *Psathyrella* ultsp. *candolleana* ,*Laxitextum* (ultsp.*bicolor*), etc.

e- Mating tests between collections from widely separated geographical localities are useful in establishing the existence of identical species from such areas. As an example, Hallenberg (1984) has presented his results of matings between isolates of Canadian and Scandinavian collections of the *Corticiaceae* and summarized the data of other studies of matings between isolates from different continents. In mating between allopatric collections, however, it is necessary to consider additionnal information (cf. further).

		A						B						
		17214	17558	17569	21205	21300	22316	F7991	17215	17547	17550	21621	21622	21624
A	17214	±	+	+	+	+	+		±	±	∓	±	+	∓
	17558	+	±	+	+	+	+		−	±	∓	∓	∓	∓
	17569	+	+		+	+	+		−	∓	∓	∓	∓	∓
	21205	+	+	+		+	+		±	±	−	±	±	±
	21300	+	+	+	+		+		∓	±	∓	∓	±	∓
	22316	+	+	+	+	+			∓	∓	∓	∓	±	±
B	F7991													
	17215	±	−	−	±	∓	∓		±	+	+	+	+	+
	17547	±	±	∓	±	±	∓		+		+	+	+	+
	17550	∓	∓	∓	−	∓	∓		+	+		+	+	+
	21621	±	∓	∓	±	∓	∓		+	+	+		+	+
	21622	+	∓	∓	±	±	±		+	+	+	+		+
	21624	∓	∓	∓	±	∓	±		+	+	+	+	+	

Fig. 5 : Strains of *Hyphoderma mutatum* can be separated in two groups, A, on *Populus* , B, on other deciduous trees, imperfectly interincompatible; ± = positive results > 50%; ∓ = positive results < 50%. (From McKeen , 1952).

Other example, the species of *Scytinostroma* with globose, amyloid spores have been accorded varied treatment by different authors. Since the heterothallic species of this group are without clamps, it was necessary to utilize nuclear staining to determine compatible matings (Lanquetin, 1973). Matings between isolates of three species, i.e., *S. portentosum* (Berk. et Curt.)Donk (in the sense of European authors, = *S. aluta* Lanq. 1984), *S. hemidichophyticum* Pouzar, and *S. duriusculum* (Berk.et Br.)Donk, from several countries (Fig.4) demonstrated the existence of three interincompatible species and the previously unrecognized presence of both *S. hemidichophyticum* and *S. duriusculum* in North America.

f- There have been several cases of partial intercompatibility reported in which the authors obtained intermediate results. McKeen (1952) found that collections of *Hyphoderma mutatum* (Peck) Donk (= *Peniophora mutata* Peck) from species of *Populus* (Group A) were imperfectly intercompatible with collections from other deciduous trees (Group B). Thus, there appear to be two partially interbreeding populations of *Hyphoderma mutatum* evolving on the two groups of substrata (Fig.5). A somewhat stronger interincompatibility apparently exists between two groups (A and B) of North American collections of *Fomitopsis pinicola* (Sw:Fr.)Karst. (Mounce and Macrae, 1938); and there is complete interincompatibility between subgroups of *Hirschioporus abietinus* (Dicks.:Fr.)Donk (Macrae, 1967). In both *Fomitopsis pinicola* and *Hirschioporus abietinus*, however, both subunits of each taxa were more or less intercompatible with some European collections. Additional cases of triangular intercompatibility are noted below.

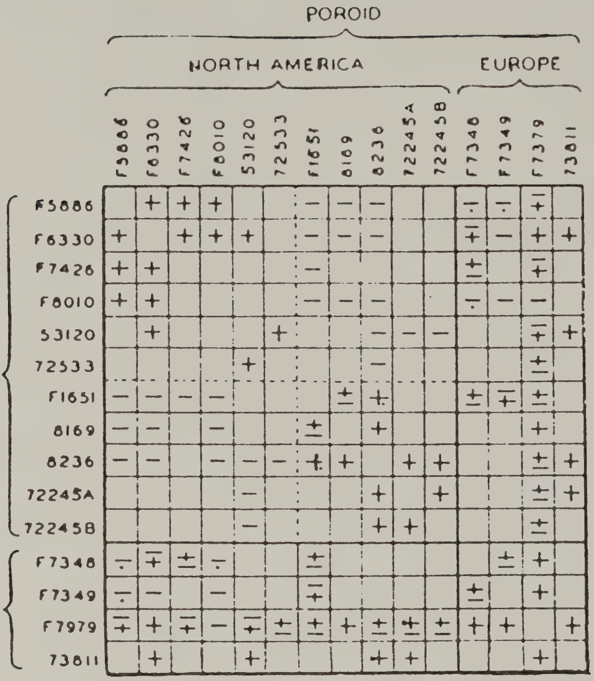
There are a number of cases of incomplete intercompatibility between different but presumed closely related species. Some examples are the reports treating *Pycnoporus coccineus* (Fr.)Bond.et Singer and *P.sanguineus* (L.:Fr.)Murr.(Nobles and Frew, 1962), *Auriporia aurea*(Peck)Ryvarden and *A.aurulenta* David,Tortić and Jelić (1974), *Typhula idahoensis* Remsberg and *T.ishikariensis* Imai (Bruehl et al.,1975), *Peniophora malençonii* Boidin et Lanquetin and *P."californica"* (Boidin and Lanquetin, 1977), etc..Six hybrid mycelia were detected among the 84 crosses between isolates of collections of *Dichostereum durum* (Bourd.et Galz.)Pilat from Europe and collections of *D.sordulentum* (Cooke et Massee)Boid.et Lanq. from N. America and Argentina (Lanquetin and Boidin, 1983). One such hybrid dikaryotic mycelium was induced to sporulate several times and produce abnormal, self-compatible (i.e., homothallic) progeny. These results tempt one to specula- that homothallic species may have originated from hybrid strains.

The European species of *Amylostereum*, *A.laevigatum* (Fr.)Boid., *A.chailletii* (Fr.) Boid., and *A.areolatum* (Fr.)Boid., are completely interincompatible; however,two collections of *A.ferreum*(Berk.et Curt.)Boid.et Lanq., one from Guadeloupe and another from Brazil, interact with European collections of *A.laevigatum* and *A.chailletii* to form dikaryotic mycelia in approximately 50 % of the matings (Boidin and Lanquetin, 1984 d). These triangular reactions in the allopatric collections of *Amylostereum* are similar to those reported by Mounce and Macrae (1938) in *Fomitopsis pinicola* and by Macrae (1967) in *Hirschioporus abietinus* described above.

I (Boidin, 1977) have proposed that it is possible that heterogenic incompatibility (Esser, 1962; Esser and Blaich, 1973) exists between some strains of the same species. In the examples studied of the species of *Amylo-*

stereum, which are morphologically and ecologically distinct, however, heterogenic incompatibility is not an adequate explanation. A more appropriate hypothesis involves the effects of climatic changes in Europe, of the disappearance of *Podocarpus*, the host of *Amylostereum ferreum*, of the adaptation to different species of Gymnospermae, and of the division of the land masses. Under these conditions the ancestral species gave rise to several divergent populations adapted to different hosts and ecological habitats. When the land masses rejoined the fungi less capable of hybridizing were favored, and the genotypes adapted to the different substrata and/or ecological habitats would not be broken up. Recombinations of these genotypes would yield progeny poorly adapted to the prevailing conditions (Dobshansky et al.,1977). This encouraged populations that became sympatric to evolve sterility barriers. The sterility barriers are complete among the three European species of *Amylostereum* ; however, the tropical American populations being isolated did not evolve the sterility mechanisms. This hypothesis also explains the triangular patterns of partial intercompatibility noted above in Mounce and Macrae's (1938) study of *Fomitopsis pinicola* and in Macrae's (1967) studies of *Hirschioporus*. It seems possible that the European population of *Fomitopsis pinicola* group C may belong to the same species as group A from North America; they are almost completely intercompatible. Group B and the sympatric group A, both from North America, are two sibling species, i.e., they are essentially genetically isolated. The intercompatibility between the European group C and the North American group B is incomplete (Mounce and Macrae, 1938), possibly because the geographical isolation did not favor the evolution of reproductive isolation.

In summary, the results of matings between monokaryotic isolates can be very useful to systematists. In many cases, the collections that mycologists hesitate to separate in different taxa, or to unite within the same species, are either entirely intercompatible and, therefore, potentially interfertile and conspecific, or completely interincompatible and, hence, of distinct species. The few cases of incomplete intercompatibility demonstrate close affinities and are best interpreted as representing taxa in the process of speciation. Mating tests also permit the definition of sibling species and support the search for reliable and distinctive taxonomic or other (i.e. parasitic or saprophytic, as in the



	POROID														
	NORTH AMERICA											EUROPE			
	F5886	F6330	F7426	F8010	53120	72533	F1651	8169	8236	72245A	72245B	F7348	F7349	F7379	73811
F5886		+	+	+			−	−	−			÷	÷	∓	
F6330	+		+	+	+		−	−	−			∓	−	+	+
F7426	+	+					−					±		∓	
F8010	+	+					−	−	−			÷	−	−	
53120		+				+			−	−	−			∓	+
72533					+				−					±	
F1651	−	−	−	−				±	+			±	∓	±	
8169	−	−		−			±		+					+	
8236	−	−		−	−	−	+	+		+	+			±	+
72245A					−				+		+			±	+
72245B					−				+	+				±	
F7348	÷	∓	±	÷			±						±	+	
F7349	÷	−		−			∓					±		+	
F7979	∓	+	∓	−	∓	±	±	+	±	±	±	+	+		+
73811		+			+				+	+				+	

Fig.6 : American strains of *Hirschioporus abietinus* divided into two interincompatible groups, but both are partially compatible with European strains (from Macrae 1967).

Armillaria ultsp. *mellea* complex) characters.(Guillaumin, 1986).

ADDITIONAL INFORMATION

It is appropriate, in my opinion, to close by encouraging mycologists to be cautious in making conclusions based on mating test results and to emphasize several precautions of which all should be aware. In fact matings of a few monokaryons in which the mating types have not been characterized by intracollection crosses can be quite misleading. In other respects, a few matings of isolates of *Amylostereum ferreum* with *A.chailletii*, or *A.laevigatum* might result in completely positive results, completely negative results, or intermediate results depending on the isolates sampled. Different experimentators could come to different and even opposed conclusions. Ideally, then, it is highly desirable to sample a sufficient large number of cultures; however, it is often not feasible, nor possible, to dispose of large samples.

There are a number of conclusions possible when working with limited samples depending on the results as follows:

a- When the matings are completely positive, i.e. in all matings clamp connections are formed and the dikaryotic hyphae gradually invade both monokaryotic colonies ,there are two possibilities:

1) If the collections are sympatric (i.e., from the same geographical areas), the two populations apparently belong to the same species; however, this conclusion should be confirmed by the induction of fertile basidiocarps yielding viable and normal progeny.

2) If the samples are allopatric (i.e., originating from different, or divided, geographical localities), the collections may belong to the same species or to two closely related species. In such cases, it is essential that a large sample be utilized. If the results are all positive with the large sample, the isolates are of one species; however, if a percentage of negative matings, intermediate results, false clamps, or unstable dikaryons are obtained, see paragraph "c" below.

b- If the results are completely negative (i.e., no clamps of any type are detected in the contact zones several weeks after the cultures were started), there are three possible explanations as follows:

1) Isolates may have become aberrant or even senescent and fail to mate with intercompatible strains, as described (Boidin and Lanquetin, 1984d) for cultures LY 8939 or 9479 of *Amylostereum chailletii*. Such monokaryons fail to form clamps in all crosses with other monokaryotic isolates of the same collection.

2) It is possible that heterogenic interincompatibility exits between isolates of the same species, as has been reported in the Ascomycotina (Esser, 1962; Esser and Blaich, 1973). Such isolates should, however, yield positive results in matings with some other strains of the same species.

3) Negative results between the isolates may indicate that the isolates represent two species that are genetically isolated. All complementary matings between the isolates of the two species are completely negative.

c- If the matings are partially positive and partially negative, or yield unstable, hybrid mycelium, there are four possible explanations as follows:

1) The species may be astatocoenocytic (Boidin, 1964, 1971; Boidin and Lanquetin, 1984a), i.e., in culture the species may produce aerial hyphae with distinct clamp connections but the submerged hyphae and hyphae at the margins of the plates lack clamps and are composed of multinucleate segments. Some authors studying such astatocoenocytic species have erroneously interpreted matings as indicative of partial intercompatibilities.

2) If the mated monokaryons have duplicate A or B factors, common A matings will give completely negative results and common B matings will yield hyphae with false clamps. The use of several monokaryons with known mating types of each isolate allows for the recognition of crosses with duplicate A and/or B factors.

3) If the matings includes a few aberrant monokaryons, positive matings will not occur in all such crosses. In such cases, the deficient monokaryons should be replaced by isolates from the same collection with identical mating factors.

4) If the above possibilities have been eliminated, matings resulting in partially positive results should be examined in detail. The percentage of negative crosses should be noted, as well as the crosses resulting in unstable, dikaryotic hyphae and those in which stable dikaryotic mycelia invades only one or both of the mated colonies.Generally, matings with intermediate results develop somewhat later than those with complete positive results, and the resulting clamped mycelia grow more slowly. When intermediate results are obtained between sympatric collections, they suggest that the taxa involved have not become completely genetically isolated. Duncan (1972) refers to such taxa as "microevolutionary units". In the case of *Hyphoderma mutatum* "A" and "B" (McKeen, 1952) ,the partially interincompatibility units are correlated with substrate. If intercompatible matings are sparse and the resulting dikaryons unstable, I would interpret such results as indicating that speciation between such units is practically complete. If the partial intercompatibilities are between allopatric collections, the collections very probably represent separate but closely related species: for instance *Amylostereum ferreum* from Central and South America and *A.chailletii* and *A.laevigatum* from Europe (Boidin and Lanquetin, 1984d); European collections of *Dichostereum durum* and North American collections of *Dichostereum sordulentum* (Lanquetin et Boidin, 1983);species of *Typhula* (Bruehl, Matchmes and K.,1975); *Vararia*

malaysiana Boidin et Lanquetin from Singapore and *V.dussii* Boidin et Lanquetin from Guadeloupe (Boidin and Lanquetin 1984a) etc.. Following this concept European collections of *Hirschioporus abietinus* should be considered as a separate species from the two North American sibling species(Macrae, 1967).(Fig.6)

In conclusion, I recommend that matings be made in Petri dishes rather than culture tubes in order to sample the margins of both mated colonies as well as the contact zone. Crosses that are negative or partially positive should be sampled again a few weeks later. In those crosses in which clamps are sparse, subcultures should be made to determine if the dikaryotic mycelium is stable. As noted above, it is most desirable to use several isolates of each mating type. Ideally, it is preferable to maintain 20 to 25 monokaryotic cultures of each collection being studied.

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PHYTOCORDYCEPS, A NEW GENUS OF THE CLAVICIPITACEAE

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Phytocordyceps C.-H. Su & H.-H. Wang is described for a single species recently found in Taiwan. The typical ascospore is characterized as ninchuka-form, consisting of two viable, multiseptate, fusiform units linked end-to-end by a long, persistent, non-nucleate, filiform connective. The host of the type species *P. ninchukispora* Su & Wang, sp. nov., is seed of *Beilschmiedia erythrophloia* Hay. (Lauraceae), a deciduous dicotyledonous tree. The anamorph is a species of *Acremonium*. Stromata with mature perithecia have been induced to develop from mated ascospore isolates.

* * * * *

Rogerson (1970) segregated a group of perithecial fungi with filiform, thick-capped asci in the Clavicipitaceae, the single family of the Clavicipitales, in which 23 genera were included. Müller and von Arx (1973), using similar concepts, keyed 18 important genera of the family, which they retained in the Sphaeriales. Criteria used in delimiting genera have been the characters of stromata, perithecia, asci, and ascospores as well as the nature of host materials; ascospore and host differences usually have been the bases for distinguishing species from each other. In line with this approach to classification of the group, the combination of a newly observed, unique ascospore form and a distinctly different host merits description of a new genus.

In 1984 and 1985, during a 5-yr survey of *Cordyceps* in Taiwan, two collections of an unusual stromatic, perithecial fungus on seeds in forest litter were made by the authors. The specimens originally were considered to represent a new species of *Cordyceps* on the basis of stroma, perithecium, and ascus characters. However, after examining mature discharged ascospores and establishing the identity of the host, we consider it feasible and appropriate to propose new genus for the single new species.

PHYTOCORDYCEPS C.-H. Su & H.-H. Wang, gen. nov.

Stromata mycelio in seminibus dicotyledonibus exorientia, lutea vel aurantiaca, stipite simplici cylindrico apice fertile clavato. Perithecia superficiaria vel bas vix immersa, pyriformia, aggregata. Asci cylindrici, apic hemisphaerico incrassato, uniperforato, haud amyloideo octospori, sine paraphysibus. Ascosporae ninchukiformes i. e., ex duabus monadibus elongatis, septatis, fusiformibu connectivo filiformi concatenatis constantes, in spora secundarias non secedentes. Typus: P. ninchukispora.

Phytocordyceps ninchukispora C.-H. Su & H.-H. Wang sp. nov
(Etym.: *nin-chuka* (Chinese dial.), an elongate, hinge handweapon similar to a flail) **Fig. 1-**

Stromata 1-6 ex quoque semine orientia, 13.8-22.4 0.3-0.9 mm; stipite 6.8-8.4 x 0.2-0.5 mm, armeniaco, poste aurantiaco; apice fertile 5.7-14.2 x 0.8-0.9 mm, unumquidqu peritheciis usque ad 800, flavo, postea bubalino, sulc longitudinali 3.2-10.1 x 0.1-0.2 mm sine peritheciis Perithecia 95-145 x 50-60 μm, pariete 5-10 μm crasso, fer superficiaria, unumquidque ascis usque ad 200. Asci unitunicati, longicylindrici, 75-105 x 2.1-3.1 μm. Ascospora hyalinae, 90-110 x 1.2 μm, ninchukiformes, partibus terminalibus fusiformibus expansis, unaquaeque 3-4-septata, 20-30 1.2 μm, binatim connectivo filiformi persistenti 60-70 x 0. μm junctis. Anamorphosis (Acremonium): mycelium hyalinum cellulis angustatis monophialidicis 30-50 x 2.0-3.0 μ hyphis conidiogenis simplicibus vel ramosissimis exorientibus; conidia hyalina, ellipsoideocylindrica, levia, 0-1-septata, 2.5-10 x 1.5-3 μm.

Typus in seminibus Beilschmiedia erythrophloia Hay. National Taiwan University Experimental Forest, Chi-Tou Nan-Tou Co., Taiwan, ROC, specimina a C.-H. Su et H.-H. Wan lecta; holotypus NTU 850106 [TAI], Jan. 1985.

Phytocordyceps Su & Wang: Stromata arising from masse of mycelium in dicotyledonous seeds clavate, yellow t orange; stalk simple (simple or branched in culture), cylindric; apical fertile portion clavate. Perithecia superficial or with base scarcely immersed, pyriform, crowded in stellate-radial arrangement. Asci cylindric, with an enlarged, nonamyloid, hemispheric apical cap penetrated by fine pore; 8-spored; without paraphyses. Ascospores con

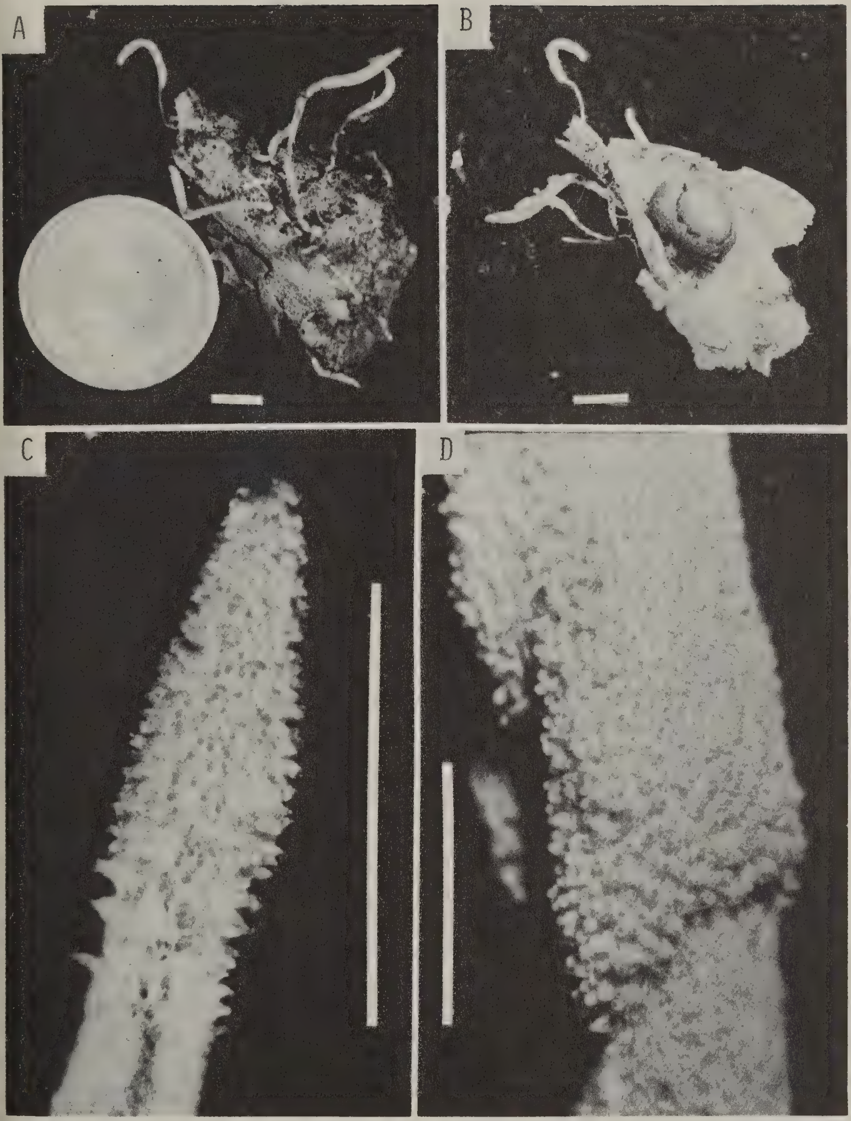

Fig. 1. Phytocordyceps ninchukispora (NTU 850106)
A. Stromata in natural position. B. Host fruit under leaf litter. C and D. Fertile portion of fruiting stromata. The bar in each figure = 50 mm.

sisting of two elongate, septate, fusoid units linked by a filiform connective; not separating into secondary spores.

Phytocordyceps ninchukispora Su & Wang: Stromata 1-6 arising from different areas of the host seed, clavate, 13.8-22.4 x 0.3-0.9 mm; stalk portion cylindric, 6.8-8.4 x 0.2-0.5 mm, apricot orange when young, becoming zinc orange to ochraceous orange; fertile portion clavate, 5.7-14.2 x 0.8-0.9 mm, maize yellow when young, becoming antimony yellow to warm buff, with a narrow longitudinal furrow 3.2-10.1 x 0.1-0.2 mm that is free of perithecia. Perithecia pyriform, 95-145 x 50-60 µm, with wall 5-10 µm thick, nearly superficial, up to about 800 per stroma (fewer in culture). Asci unitunicate, long cylindric, 75-105 x 2.1-3.1 µm, as many as 200 per perithecium. Ascospores hyaline, 90-110 x 1.2 µm, ninchuka-form; with expanded fusoid end parts, each 3-4 septate, 20-30 x 1.2 µm, joined end-to-end in pairs by a persistent 60-70 x 0.1 µm filiform connective; not separating into secondary spores, but germinating directly into hyphae. Anamorph (*Acremonium*) developing in 1-ascospore isolates): mycelium of uninucleate cells 1.0-1.5u,m diam, hyaline, producing monophialidic cells 30-50 x 2.0-3.0 µm in a simple to highly branched conidiogenous system. Conidia hyaline, ellipsoid-cylindric, slightly curved, smooth walled, 0-1 septate (cells uninucleate), 2.5-10 x 1.5-3 µm.

Type: on seed of *Beilschmiedia erythrophloia* Hay., coll. at National Taiwan University Experimental Forest, Chi-Tou, Nan-Tou Co., Taiwan, R.O.C., by C.-H. Su and H.-H. Wang; **holotype** NTU 850106 [**TAI**], Jan. 1985; representative coll. (as permanent slide) [**TAI**], June 1984; representative cultures ATCC, CBS, CMI, FIRDI, IFO.

Phytocordyceps ninchukispora stromata, perithecia, and asci have a strong family resemblance to those of species of *Cordyceps* (Mains 1954; Kobayasi 1982) and *Claviceps* (Rogerson 1970). The ninchuka-form ascospore, however, is unique and readily distinguishable from any ascospore described for any of the very numerous published species of *Cordyceps* and its segregates and of the several species of *Claviceps*.

Most species of the Clavicipitaceae have insects, spiders, or other fungi as hosts, plus the graminicolous and cypericolous hosts of *Claviceps* species. Other genera previously described from fruit substrates include *Shimizuomyces* Kobayasi (1981) with species on fruits of *Smilax sieboldii* and *S. china* (Smilacaceae), and *Neocordyceps* Kobayas (1984) with a species on fruits of *Tripterospermum japonicu* (Gentianaceae). The immersed perithecia and typicall

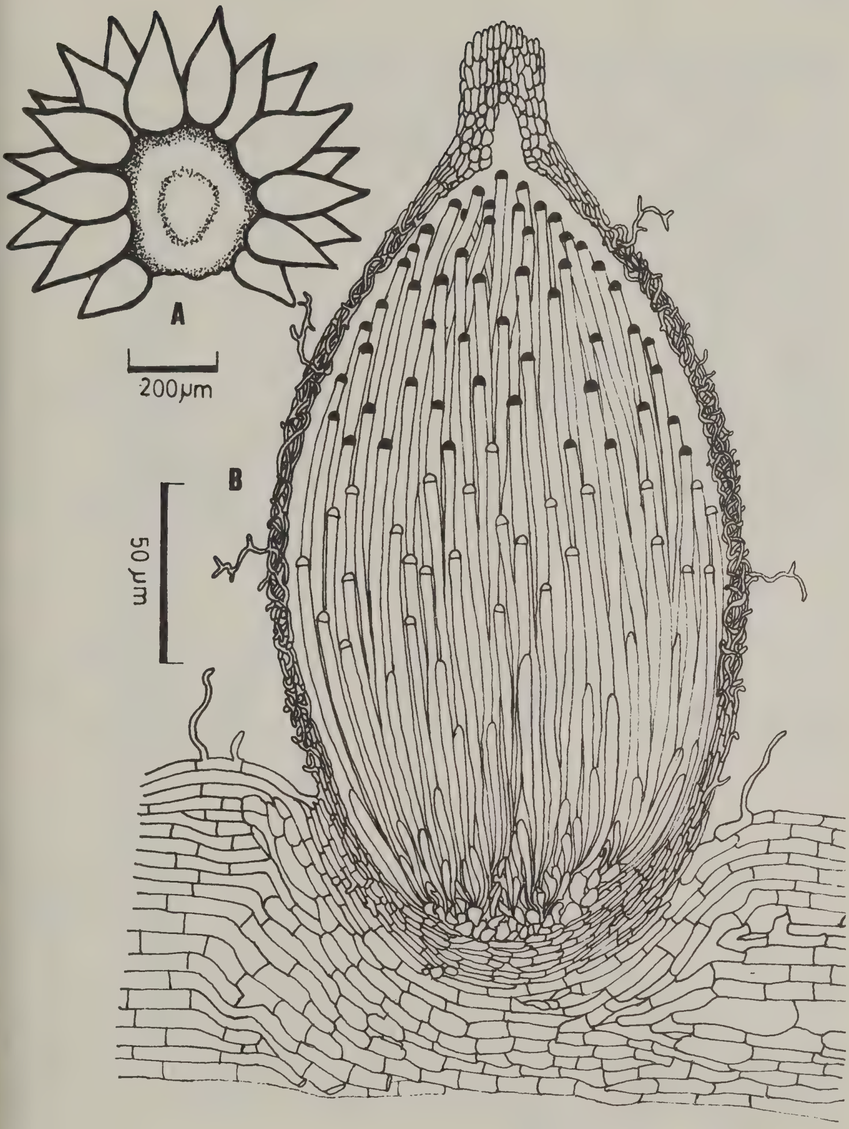
A
200µm
B
50 µm

Fig. 2. Phytocordyceps ninchukispora (NTU 850106)
A. Perithecia on stroma in cross-section. B. Perithecium with asci.

fusiform ascospores of these two fungus genera readily serve as characters distinguishing them from *Phytocordyceps*.

Very few species among the Clavicipitaceae have been reported to produce mature stromata in culture (Kobayasi 1941; Basith and Madelin 1968; Pacioni and Frizzi 1978). *Phytocordyceps ninchukispora* has been induced to produce stromata and mature perithecia consistently and abundantly on supplemented potato/dextrose agar. Initial success involved extracts of fallen leaves from 13 species of trees representing 7 dicotyledonous families; the extract of each species sample was individually effective as a PDA supplement. Fractionation, paper-disc diffusion, and chromatography techniques subsequently were used to identify asparagine and tetracycline or its analogues as the effective extract components. The details of this biochemical work form part of the doctoral thesis of C.-H. Su (1985), based on research studies in the Graduate Institute of Agricultural Chemistry, National Taiwan University, Taipei, Taiwan, ROC.

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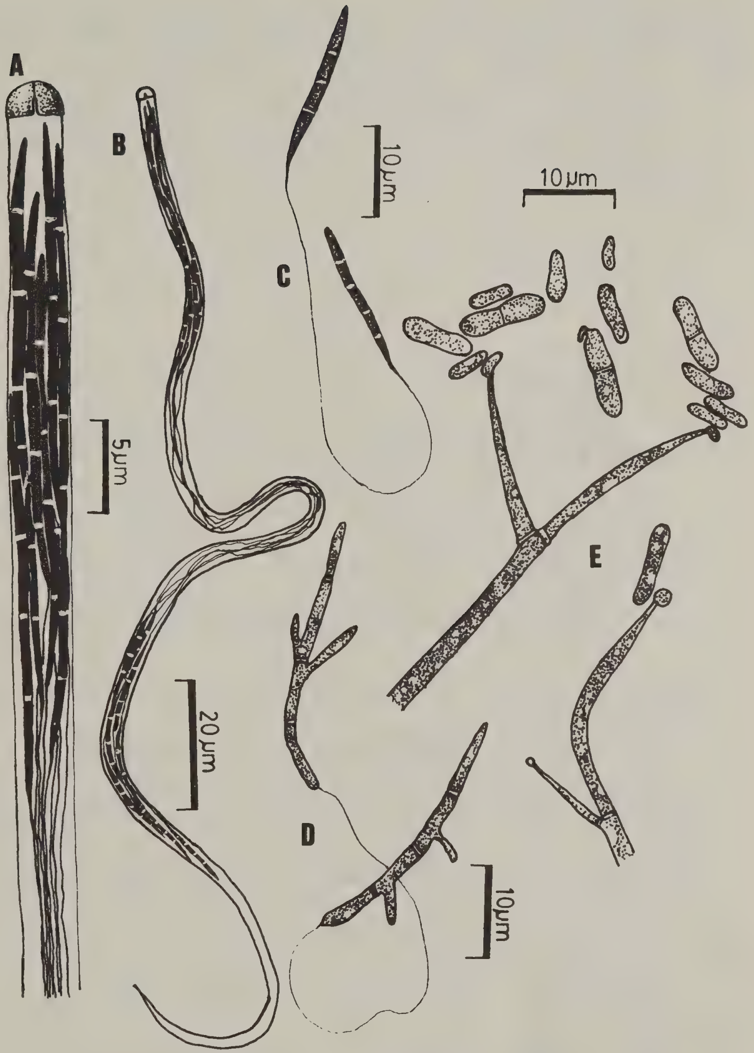
A
B
C
D
E
5µm
20µm
10µm
10µm
10µm

Fig. 3. Phytocordyceps ninchukispora (NTU 850106)
A. Top part of ascus. B. Ascus. C. Ascospore.
D. Germinating ascospore. E. Conidiophores and conidia.

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中文摘要

植生蟲草屬（*Phytocordyceps* C.-H. Su et H.-H. Wang）爲最近於台灣發現之新眞菌屬，本文以其單一種進行描述。本屬之典型特徵爲具有雙節棍型子囊孢子，係由兩端具有成活力，多隔膜，梭形之兩部份，由一持久性，無細胞核之細長絲狀部份加以連繫（頭尾相連）。本屬模式種稱爲雙節棍孢子植生蟲草（*P. ninchukispora* Su et Wang sp. nov.）其寄主爲瓊楠（*Beilschmiedia erythrophloia* Hay.）係樟科之落葉喬木，與形態近之蟲草屬（*Cordyceps*）及麥角菌屬（*Claviceps*）之寄主，諸如：昆蟲、蜘蛛、眞菌，或禾本科及莎草科植物有顯著不同。本屬之無性世代爲*Acremonium*之一種。經由單一子囊孢子萌發產生純培養菌株交配後可得具有成熟子囊殼之菌座。

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EUPENICILLIUM CRYPTUM SP. NOV., A FUNGUS WITH SELF-LIMITING GROWTH AND RESTRICTED CARBON NUTRITION

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ABSTRACT

Eupenicillium cryptum Gochenaur from soil of an oak-birch forest is described and illustrated. The teleomorph produces small, smooth-faced ascospores with a pair of widely separated ridges. The anamorph has simple and one-staged branched conidiophores and small, smooth or finely roughened, thin-walled conidia. Self-limiting growth, an unstable colonial morphology, abundance in a soil ecosystem and a highly restricted carbon nutrition set *E. cryptum* apart from other species in the genus. The possibility of a root-inhabiting existence for this fungus is discussed.

INTRODUCTION

For the past twelve years, isolates of a slow-growing *Eupenicillium* have been obtained repeatedly from the A horizon of an oak-birch forest on Long Island (10, 33). On rose bengal isolation plates (10), it appears after approximately 12 days incubation at room temperature as a tiny, white colony consisting of a few aerial hyphae and conidiophores and numerous small hyaline cleistothecia. Initially, subculturing of the organism always ended in failure because ascomatal colonies were quickly overrun by faster-growing colonies producing only conidiomata. These two distinct colony types are designated in this paper as the holomorph and anamorph, respectively. Study has revealed that the holomorph can be maintained in culture by exploiting some of its unique attributes. It is described herein as a new species and its nutrition and cultural instability are examined.

The holotype, a desiccated agar culture (No. 769), is deposited in The New York Botanical Garden Herbarium, Bronx, New York and an isotype in the Herbarium at the Commonwealth Mycological Institute, Kew, England. Living representative strains have been placed in the American Type Culture Collection, Rockville, Md. (ATCC 60138), the Northern Regional Research Laboratory Collection (NRRL 13460), and the National Culture Collection, Commonwealth Mycological Institute (IMI 296794).

MATERIALS AND METHODS

Morphological descriptions are based on a cloned culture derived from a single ascospore and maintained on malt extract agar (MEA), consisting of 2% glucose, 2% malt extract, 0.1% peptone and 2.5% agar at 20 and 25 C. Colors refer to plates in the Methuen Handbook of Colour (16). All drawings were made with the aid of a camera lucida.

Carbon (C) nutrition of *Eupenicillium cryptum* was done in five cm petri dishes containing the basal medium (10 ml) and a substrate overlayer (4 ml). The basal medium contained per liter 1 g $(NH_4)_2SO_4$, 0.5 g KH_2PO_4, 0.1 g $MgSO_4 \cdot 7\ H_2O$, 100 µg Fe+++, 100 µg Zn++, 50 µg Mn++ and 1.5 g Bacto-Purified Agar (Difco Laboratories, Detroit, Michigan). The substrate overlayer contained 0.5% or 1.0% of the substrate in water and was solidified with 1.5% Bacto-Purified Agar. A concentrated solution of Bacto-Yeast Nitrogen Base without ammonium sulfate and amino acids (YN-N) was filter sterilized and added to each substrate overlayer to yield a final concentration of 0.117%. YN-N supplied B-vitamins and trace elements. All diffusible substrates and inulin were filter sterilized and used at a level of 1.0%. The non-diffusible substrates (amylopectin, cellulose, chitin, dextran - m.w.200,000 to 300,000, glycogen, pectin, and xylan) were heat sterilized (121 C, 10 min) and used at a level of 0.5%. Colloidal chitin and crystalline cellulose were prepared by the methods of Hsu and Lockwood (15) and Walseth (30), respectively. All monosaccharides were D-isomers except L-sorbose, L-arabinose, L-fucose and L-rhamnose. All diffusible substrates were reagent grade and were purchased from ICN Pharmaceuticals, Cleveland, Ohio.

The nitrogen (N) and vitamin nutrition of *E. cryptum* were studied in a manner identical to the carbon utilization study. For the N study, ammonium sulfate was omitted and 1.0% glucose was added to the basal medium. The substrate overlayer contained 0.1% substrate dissolved or suspended in water, 0.117% filter-sterilized YN-N and 1.5% Bacto-Purified agar. Bacto-Gelatin and -Sodium Caseinate were heat sterilized (121 C, 10 min). All other substrates, Bacto-Vitamin-free Casamino Acids, sodium nitrate, sodium nitrite, ammonium sulfate, urea, aspartic acid, glutamic acid, and asparagine, were filter sterilized. For the vitamin study, YN-N was omitted from the basal medium. The overlayers contained either no vitamins, biotin (2 µg/liter), thiamine (200 µg/liter), biotin plus thiamine, or YN-N.

Inoculum for the C, N, and vitamin studies consisted of ascospores derived from white masses (Fig. 2C) or conidia suspended in the basal medium containing 0.009 g glucose per liter. YN-N was omitted from the basal medium used to grow inoculum for the vitamin study. The plates were incubated at room temperature for 3 da, and then a stack of sterile, single edge razor blades was used to cut the agar at right angles. This provided uniform inoculum of two mm^2 agar cubes. The experiments with the holomorph and anamorph were run in duplicate. Cultures were

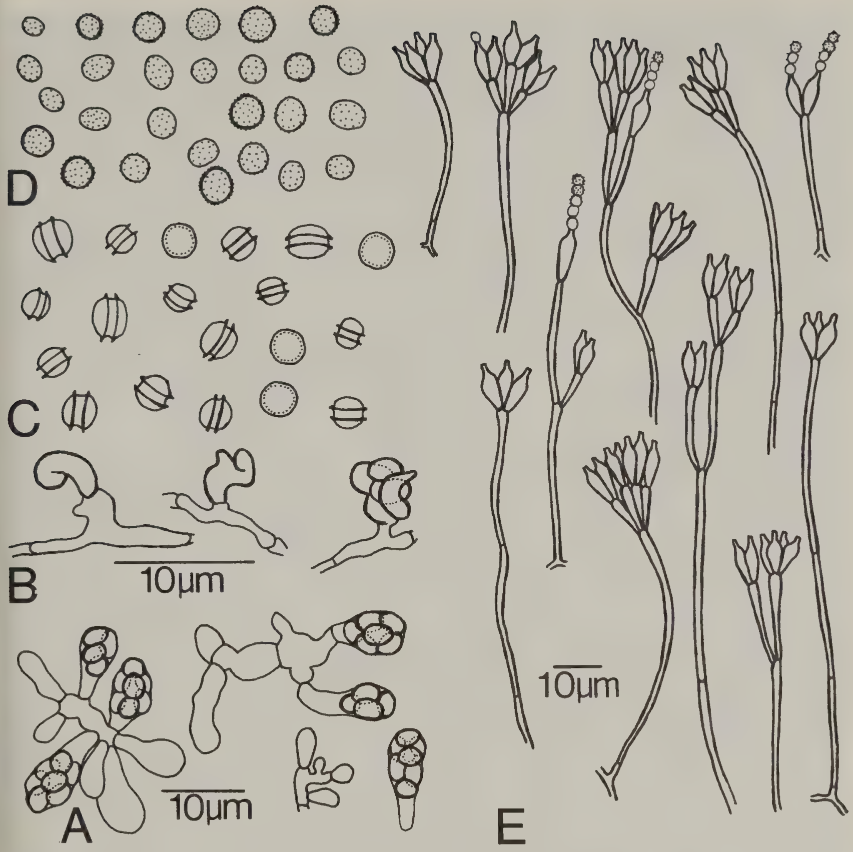

Fig. 1. *Eupenicillium cryptum.*
(A) Asci borne singly. (B) Ascospores. (C) Conidia.
(D) Conidiophores.

incubated for 35 da at 20 C. The positive control media contained glucose for the C study, ammonium sulfate for the N study and YN-N for the vitamin study. The negative control media lacked these compounds.

The utilization of amino acids as a sole carbon source was tested in triplicate in static liquid culture at 20 C for 18 da. A basal medium consisting of 0.117% YN-N and 1.0 g $(NH_4)_2SO_4$ per liter with 1.0% Bacto-vitamin-free Casamino Acids (CA) as the C source, without CA (- control) or with 1.0% glucose (+ control) was filter sterilized and dispensed in 10 ml amounts into sterile 125 ml flasks capped with 50 ml beakers. Inoculum was 0.1 ml of a heavy aqueous suspension of conidia or ascospores. After incubation, growth was assessed by collecting each fungal

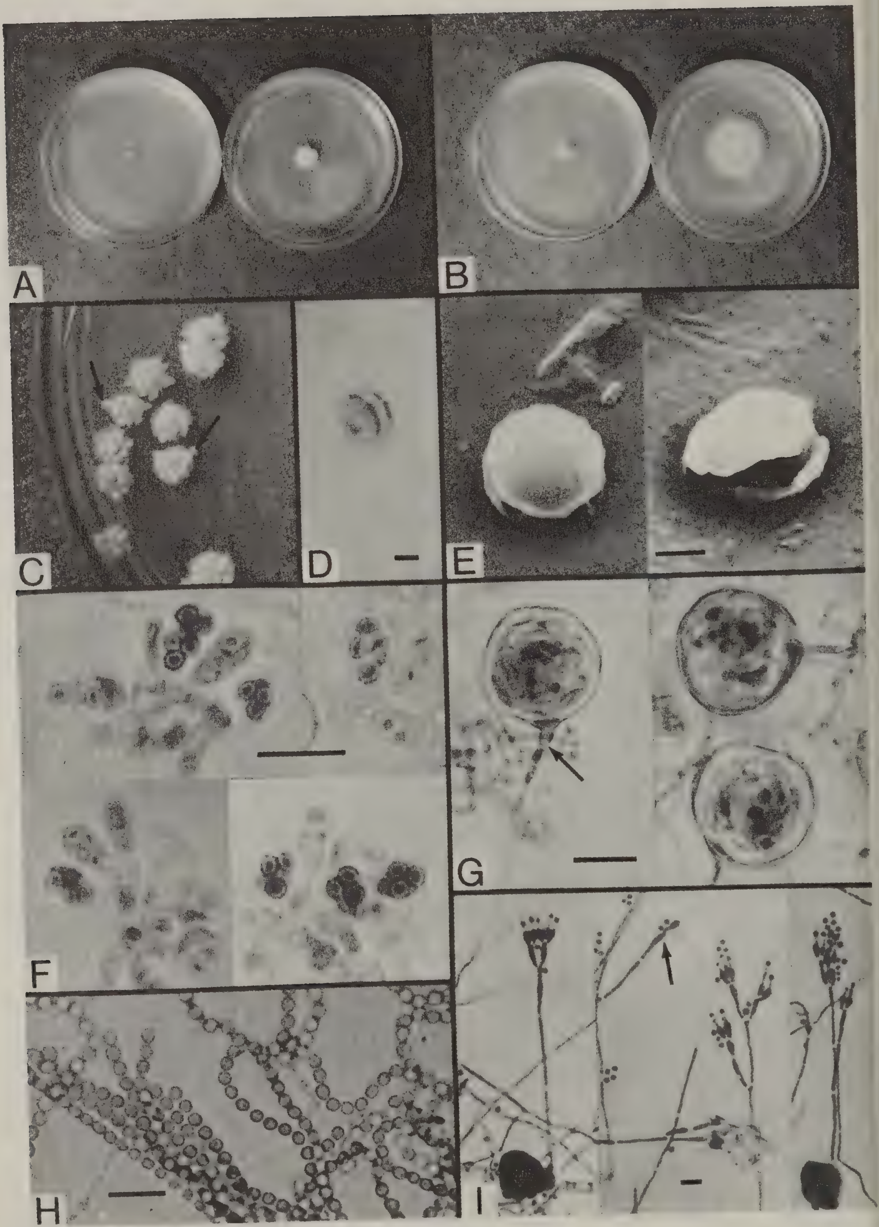

Fig. 2. *Eupenicillium cryptum.*
Holomorph (A) and anamorph (B) on Czapek-Dox agar (left plate of each pair) and malt extract agar in 5 cm petri dishes after 18 days at 20 C. (C) Cloned colonies, 45 days

mat on a tared nitrocellulose filter and then drying it to a constant weight at 60 C.

Studies on the effect of temperature and pH on the growth of the holomorph used BBL-Cornmeal Agar (Baltimore Biological Laboratories, Cockeysville, Maryland). The pH of the medium was adjusted after sterilization to the desired level using 3N HCl or NaOH and the cultures incubated for 25 da at 20 C. Inoculum derived from ascospores was used. The temperatures and H-ion concentrations tested were 5, 10, 15, 20, 25, 30 and 35 C and pH 2.0, 3.0, 4.0, 5.0, 6.0, 7.0 and 7.5 respectively.

Osmophilic growth of the holomorph and anamorph was studied on BBL-Cornmeal Agar with 0.1% glucose prepared in 0, 1, 5, 10, 20, 30 and 50% sucrose solutions (w/v), a non-metabolized substrate. Inoculum consisted of ascospores or conidia; incubation was for 25 da at 20 C.

Conidial germination and mycelial growth on MEA under anaerobiosis was tested in triplicate at room temperature using BBL-Gas Pak System with methylene blue indicator. Cultures incubated in air were the experimental control.

Growth rate of the holomorph and anamorph was compared to that of *Penicillium javanicum* van Beyma (NRRL 707) [= *Eupenicillium javanicum* (van Beyma) Stolk & Scott var. *javanicum* Stolk & Sampson] on MEA at 20 C. The mean size of the colony was calculated from measurements made along two diameters at right angles on quadruplicate cultures at various times up to 20 da.

Holomorph stability at various temperatures was studied on slants of MEA. White masses were removed from a five-month old culture, suspended in a drop of water, and then streaked over the surface of an MEA plate. After incubation, 25 well-isolated holomorphic colonies were each cut into 4 pieces and these pieces used to inoculate MEA slants. The four subcultures from each colony were incubated at 15, 20, 25, and 30 C., examined periodically over 68 days, and the presence or absence of mutant sectors recorded.

TAXONOMY

Eupenicillium cryptum Gochenaur, spec. nov. Figs. 1-2
Status conidialis: *Penicillium cryptum* Gochenaur, stat. nov.

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old, derived from ascospore inoculum showing development of white masses (arrows). (D) Single ascospore with widely spaced equitorial ridges (brightfield microscopy). (E) Scanning electron micrograph of ascospores showing smooth faces. (F) 8- and 4-spored asci. (G) Mature ascomata exhibiting "stalk" cell (arrow), peridial wall consisting of a single cell layer and ascospores. (H) Wet mount showing persistant chains of conidia. (I) Conidiophores, one with a single phialide (arrow). Material in photographs F-I was stained with cotton blue. Bars in D and E represent 1 µm; others 10 µm.

Coloniae holomorphosis in agaro maltoso tarde crescunt, ad 6-8 mm crassae post 14 dies 25 C; coloniae in agaro Czapeckii non crescentes; superfeciei pisacae vel griseo-viride; incolorato vel abolutescens reverso. Cleistothecia minuta, (18-) 22-32 (-40) μm crassa, cum stirpe, parce sclerotioidea vel pseudoparenchymata, primo hyalina, demum alutaca, glabrata, post 2-3 hebdomades maturescenti. Asci 6-8 x 5-6 μm, singuli et laterales in hyphis ascogonicis, subglobosi vel ellipsoidei, octospori vel parce tetraspori, evanescentes. Ascosporae 1.8-2.0 x 2.2-2.5 (-3.0) μm oblatae, hyalinae, unicellares, laevibus convexis partibus, duabus costis late distantibus ad 1.0 μm latis praeditae. Conidiophora hyalina, 8-50 (-90), interdum 200 μm alta, 2.2-2.5 μm lata, laevia. Penicilli variabiles, monoverticillati vel asymetrici vel ramigeni. Rami 8-15 x 2.2-2.5 μm. Metulae 2-3 (-4) per verticillum, 6.0-10.0 x 2.2 μm. Phialides 1-5 per metulam, 5.5-8.0 x 2.2-2.6 μm, 2.0 μm longo tubu osto. Conidia globosa vel subglobosa, (1.5-) 2.0-2.5 (-3.0) μm in diam., minute spinulosa, hyalina.

Holotypus: e terra Querceto-Betuleti isolatus, Hempstead Lake State Park, L.I., N.Y., October, 1983 (cultura desiccata #769, Herb., NY).

Etymology: Latin cryptus = hidden, referring to its function in the soil ecosystem.

Holomorphic colonies on MEA at 25 C (Fig. 2A), very slow-growing, 6-8 mm after 14 da, surface pea green (29D5); texture velvety; margin arachnoid and irregular; reverse uncolored or drab golden blond (5C4) shading to dull yellow (3B3); no exudate or odor; conidiophores arising in a thin, even stand throughout the colony or appearing especially dense along the leading hyphae making-up the arachnoid margin; ascomata evenly scattered, sometimes in dense clusters; growth thin or absent on Czapek-Dox with glucose or sucrose; homothallic.

Ascomata developing from a knot of irregularly wound hyphae; very small (Fig. 2G), (18-) 22-32 (-40) μm, globose, less commonly subglobose, borne from the end of a stipe-like hyphal branch, glabrous, hyaline, becoming pale beige at maturity, at first weakly sclerotioid, consisting of a few irregular thick-walled cells, at maturity soft with the peridium composed of one layer of cells through which the mature ascospores can be seen; maturation rapid, often occurring within 15 da at room temperature in colonies freshly isolated from nature; sub-cultures often not ripening at all. *Ascogenous hyphae* straight or with slightly sinuous branches (Fig. 1A). *Asci* clavate when young (Figs. 1A, 2F), 9-10 x 5-6 μm, becoming oval at maturity, 6-8 x 5-6 μm borne singly, 8-spored, less commonly with 4. *Ascospores* (Figs. 1C, 2D-E) 1.8-2 x 2.2-2.5 (-3.0) μm, hyaline, lenticular with 2 widely separated equatorial crests 0.5 μm high and up to 1.0 μm apart, valves appearing essentially smooth when viewed with light and scanning electron microscopy; not constitutively dormant, germinating after 22 hrs at room temperature.

Conidiophores variable (Figs. 1E, 2I), ranging from simple to one-stage branched, in rare cases two-staged branched, with a verticil of 2-3 (-4) slightly divergent metulae sometimes of unequal length, or less commonly ramigenous with a terminal phialide or cluster of phialides and one or more secondary conidiophores, arising singly at different levels from the stipe. *Stipes* variable in length, 8-50 (-90) x 2.2-2.5 μm, sometimes up to 200 μm long, non-vesiculate, smooth-walled, unpigmented. *Metulae* 6.0-10.0 x 2.2 μm, smooth-walled. *Phialides* in clusters of 2-5, less commonly single, typically small, 5.5-8.0 x 2.2-2.6 μm, consisting of a cylindrical to somewhat narrowed base and a swollen middle that tapers abruptly into a conspicuous, narrow neck about 2 μm long. *Conidia* (Figs. 1D, 2H) (1.5-) 2.0-2.5 (-3.0) μm, oval to slightly fusiform and thin-walled when young, globose to subglobose at maturity, hyaline to pale amber, smooth to finely roughened, borne in long tangled chains that persist in wet mounts in chains of up to 50 cells (Fig. 2H).

Anamorphic colonies on MEA at 25 C (Fig. 2B), 14-16 mm after 14 da; growth thin; surface plane, medium yellow green (30C6), shading to pale yellow green (30B6) near the margin; margin thin, hyaline, regular; no exudate or odor; growth on Czapek-Dox with glucose or sucrose, very thin and sparse.

ECOLOGY

All forty described species of *Eupenicillium* have been recorded from soil (23, 26). The majority (48%) are known only from the type locality; some (20%) from a particular country or continent; while the remainder (32%) are widely but sporatically distributed. None, with the possible exception of *E. pinetorum* Stolk (4), is locally abundant.

Eupenicillium cryptum is a widespread and characteristic fungus of an oak-birch forest soil on Long Island and has, therefore, a distributional pattern unique among the eupenicillia known to date. It was one of five broad-amplitude species in the initial dilution plate survey of microfungi occurring in the A horizon of the forest conducted between January, 1974 and April, 1977 (10). A second survey done between July, 1979 and April, 1980 using the selective Warcup Soil Steaming Technique found *E. cryptum* to be the most common cleistothecial ascomycete in the A horizon (33). Its distribution in this ecosystem during the year 1974 (Fig. 3), is representative of the results obtained throughout the initial survey (10). *E. cryptum* was somewhat more abundant in winter and early spring than it was during the other seasons. It had a yearly average density of 17,600 ±1,600 (S.E.) per gram of soil and a high frequency of occurrence in the 30 samples studied each month.

NUTRITION

Eupenicillium cryptum is an obligate aerobe. Its conidia do not germinate but remain viable and hyphae do not increase in length during a 9-day exposure to anaerobiosis. It is mesophilic with growth occurring between 15 and 30 C; development is optimal at 20 C. Conidia swell but do not germinate at 5 and 37 C. Growth takes place over a wide range of H-ion concentrations and at every pH tested but was greatest between pH 3 and 4. *E. cryptum* is weakly osmophilic. The holomorph has identical colony diameters on 0% through 10% sucrose agar; growth occurred but was restricted at the higher levels tested. The anamorph showed maximum growth and conidiogenesis on 10% sucrose agar.

Nutritional results for both the holomorph and anamorph were identical. *E. cryptum* utilized various nitrogen sources but could not grow on nitrate or nitrite nor hydrolyze the proteins, gelatin and casein (Table I). Its carbon nutrition is extremely limited, even though a trace amount of "start" glucose was included in the inoculum. Less than half of the monosaccharides, alcohols and acids tested (Table II, compounds numbered 1 through 17), only one of the di and trisaccharides (compounds numbered 18 through 25), and none of the polysaccharides or vanillin, were utilized. It could hydrolyze Tween 80 and use oleic acid for growth but not conidiogenesis. Amino acids provided an excellent source of carbon and produced three times more biomass than occurred on glucose. Colonies on a medium lacking vitamins were identical to those on media containing vitamins when point inoculations were used or when the entire surface of these media was inoculated with conidia. We interpret these results as indicating that *E. cryptum* does not require vitamins for growth.

GROWTH RATE

Eupenicillium cryptum has an exceptionally slow growth rate in culture. This is illustrated in Fig. 4A where it

Table I. Growth of *Eupenicillium cryptum* on various nitrogen sources.

Compound	Growth*)	Compound	Growth
1. Sodium nitrate	–	6. Glutamic acid	++
2. Sodium nitrite	–	7. Asparagine	++
3. Ammonium sulfate	++	8. Casamino acids	++
4. Urea	+	9. Gelatin	–
5. Aspartic acid	++	10. Sodium caseinate	–

*)++ Growth equal to growth on ammonium sulfate.

+ Growth weak but better than growth on a medium lacking a nitrogen source.

– Growth equal to the negative control.

Table II. Growth of *Eupenicillium cryptum* on various carbon sources.

Compound	Growth*)	Compound	Growth
1. Glucose	++	19. Lactose	-
2. Mannose	++	20. Cellobiose	++
3. Galactose	-	21. Trehalose	-
4. Fructose	++	22. Sucrose	-
5. Sorbose	-	23. Melibiose	-
6. Xylose	++	24. Raffinose	-
7. Arabinose	++	25. Melezitose	-
8. Ribose	-	26. Amylopectin	-
9. Fucose	-	27. Glycogen	-
10. Rhamnose	-	28. Inulin	-
11. Glycerol	+	29. Dextran	-
12. Erythritol	++	30. Pectin	-
13. Mannitol	-	31. Xylan	-
14. Sorbitol	-	32. Cellulose	-
15. Na·Acetate	+	33. Chitin	-
16. Na·Succinate	-	34. Tween 80	+
17. Na·Citrate	-	35. Vanillin	-
18. Maltose	-	36. Casamino acids	++

*)++ Growth equal to or better than growth on glucose.

+ Growth weak but better than growth on a medium lacking a carbon source.

- Growth equal to the negative control.

is compared with *E. javanicum*, a species with moderately rapid growth. Note that *E. javanicum*'s colony expansion is six to ten times as fast as the *E. cryptum* anamorph and holomorph respectively. Only two described species, *E. lassenii* Paden and *E. fractum* Udagawa, have strains that produce colonies on MEA with diameters of less than 10 mm in 7 days at 25 C (23); but even these have growth rates approximately twice as fast as that shown by the *E. cryptum* holomorph. Fungal cell lines harboring viruses may grow slowly (31) but we have no evidence that this is the case with *E. cryptum*.

During the first 10 days when the growth rate of both *E. cryptum* colony types is linear (Fig. 4A), ones developing only conidiomata (anamorph) grow more rapidly than those producing predominately ascomata (holomorph).

We believe this shows sexual development to be a process more demanding of resources and energy than asexual development and as a consequence less of these commodities are available for radial extension. Thus, reproduction and growth can be viewed as competitive processes; a phenomenon well documented for plants (14) and animals (22).

The holomorph exhibits self-limiting growth (Fig. 4A) that coincides with the formation of ascomata. In other words, after ten days, the increase in colony diameter becomes negligible even though fresh nutrients and agar surfaces are available to the fungus.

Auto-inhibition of spore germination is well documented in the literature (18) but similar studies on the effect of inhibitor compounds on hyphal growth are rare. Romanos et al. (24) have shown that certain strains of *Gaeumannomyces graminis* v. *tritici* produce an inhibitor called the Q Factor, a low molecular weight, non-proteinaceous, diffusible molecule. Producer isolates develop more slowly in culture than non-producer strains suggesting that the producer is sensitive to the inhibitor it secretes. A reduction in pathogenicity after a period in culture also appears to be correlated in this variety with increasing potential to produce inhibitor (21). A species of *Macrophoma* (25) and *Aspergillus sydowi* Bain. & Sart.) Thom & Church (27) also are reported to form self-inhibiting compounds.

Our results with *E. cryptum* could be explained by the production of an inhibitor during sexual reproduction that is suppressive to its own growth. An unlikely explanation (2) is that radial expansion ceased when the synthesis of some growth-promoting factor or the production of some organelle was not sufficient to keep up with the increasing number of hyphal tips developed by the expanding colony since the phenomonen was not observed with the anamorph.

HOLOMORPH STABILITY AND MAINTENANCE IN CULTURE

Colonies of *E. cryptum* grown from a soil inoculum have an identical appearance that resemble those derived in culture from ascospores. Each is minute and predominately cleistothecial. Conidiophores are uncommon. This uniform appearance suggests that in nature selection pressure operates against the anamorph or that fresh isolates may carry factors that suppress conidiogenesis.

Subcultures of these soil isolates invariably produce within a few weeks sectors that completely overgrow the holomorph. If the organism was heterokaryotic when isolated from nature than elimination of selection pressure in culture could result in a shift in the ratio of genetically-different nuclei (1, 20) and/or extrachromosomal elements (3). If it was homokaryotic than the culture environment could induce repression or enhancement of one or more genes concerned with development. In either case, the end result is a shift towards enhanced conidiogenesis or sterility and a loss of the teleomorph. Although in this paper we are treating self-limiting growth and sectoring as separate phenomena, there is nothing to

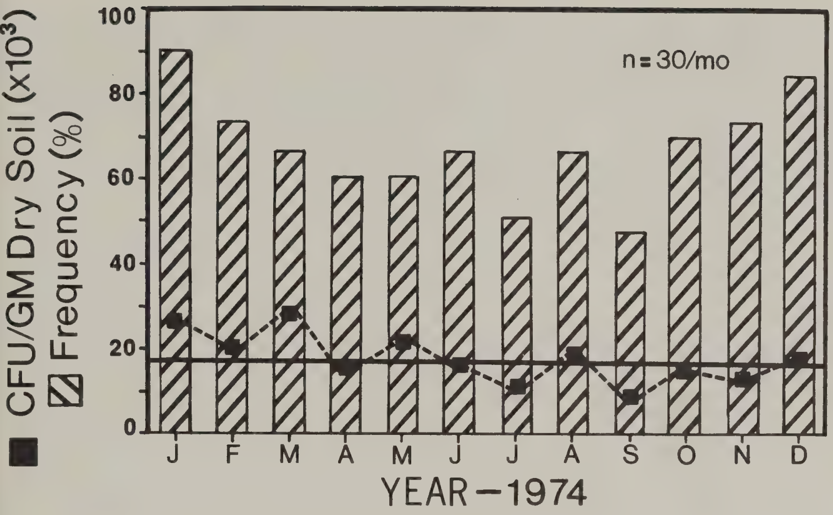

Fig. 3. Distribution of *Eupenicillium cryptum* in the A horizon soil of a Long Island oak-birch forest during 1974. Horizontal line represents mean colony-forming units (CFU) per gram dry soil per year. Frequency is the percentage of samples out of 30/month that yielded *E. cryptum*.

preclude these responses being caused by the same factor.

The rate of sector production is temperature dependent (Fig. 4B). At 30 C, 100% of the twenty-five subcultures showed sectors after two weeks incubation but at 15 C none was produced during this time. No mature ascomata developed in the latter cultures or in ones incubated at 20 C. It appears that higher temperatures favor sexual development while concurrently increasing the likelihood that colonies will sector.

In the above experiment, 128 sectors were examined. Four types occurred with some colonies showing more than one kind. The majority (72%) were rapidly-growing and strictly conidial; the remainder sterile. Among the latter were ones composed of white aerial mycelium that either grew more rapidly than the parent colony (6%) or at the same rate (12%) and those that were subsurface, beige in color, fast-growing and arachnoid in appearance (10%).

The problem of sectoring made maintenance of the holomorph in culture difficult. We found that sectoring was enhanced when a single inoculation point was used and repressed when the agar surface was completely inoculated. Experimentation showed that repressed sectoring in point inoculated colonies could not be achieved by varying nutrient ratios or levels.

In crowded cultures, some colonies develop white, cauliflower-like masses (Fig. 2C) up to 1 mm in diameter following several weeks incubation at room temperature (ca. 22-23 C). When examined microscopically, these masses are found to contain a mixture of asci, mature ascospores and short hyphal elements (immature asci?) but no peridial walls. All of these elements are capable of "germination" when streaked on an appropriate medium. We view these masses as a culturally-induced abnormality and one that is probably not produced by the organism in nature. At present the genetic and/or environmental factors that trigger their development are unknown.

When material is removed from a mass, conidial contamination is unavoidable. If the mass is homogenized in a drop of water and then streaked out over the agar surface, many of the colonies that develop are holomorphic and produce more white masses and/or mature ascomata (Fig. 2F); the remainder, possibly derived from conidia, are anamorphic. If plates containing ascospores are then sealed with parafilm, they can be stored for up to one year at room temperature. As the cultures age, the number of viable conidia decreases so that after a year almost all colonies developing from the masses are holomorphic. It is through this process that *E. cryptum* is currently being maintained in culture.

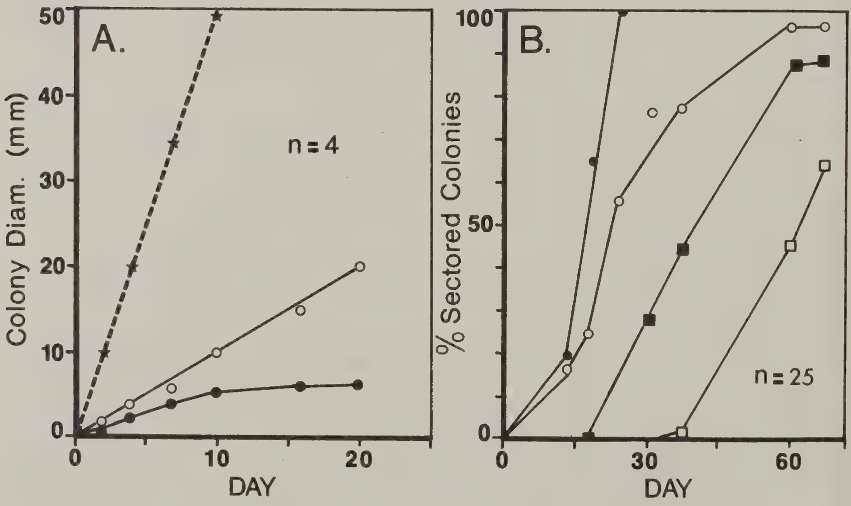

Fig. 4. Growth and colony-sectoring rates of *Eupenicillium cryptum in vitro*. (A) A comparison of the growth rate of *E. cryptum* holomorph (closed circle) and anamorph (open circle) to *E. javanicum* (dotted line) on malt extract agar at 20 C. (B) Rate of sector production by *E. cryptum* holomorph on malt extract agar at 15 (open square), 20 (closed square), 25 (open circle) and 30 C (closed circle).

DISCUSSION

Eupenicillium cryptum exhibits a combination of morphological, physiological and cultural characteristics distinct from all described species. It can be accommodated in Section Lapidosa (Pitt) Stolk & Sampson (26) on the basis of ascospore and anamorph morphology. Superficially, the small size of its elements and weakly osmophilic growth places it closest to *E. parvum* (Raper & Fennell) Stolk & Scott. It differs from this species in having ascospore faces that are smooth rather than ones showing irregular, anastomosing ribs. *E. parvum* also has completely different cultural characteristics (23), growth rates (23) and nutritional requirements (unpublished data). *E. cryptum* resembles members of the Series Fracta Pitt (23) and *E. lasseni* (Series Tularensia Pitt) by growing very slowly in culture but differs from all of these except *E. meloforme* Udagawa & Horie (Series Fracta) in not developing at either 5 or 37 C. Morphologically and culturally, *E. meloforme* and *E. cryptum* are distinct.

Eupenicillium cryptum is a common and persistant fungus in a L. I. oak-birch forest soil and one whose holomorph is readily isolated in culture, presumably through its ascospores (33). Even so, its slow growth and limited carbon nutrition *in vitro* suggest that it should compete only poorly with other members of the soil community.

Harley and Smith (13) on the basis of carbon nutrition partition soil fungi into three catagories, namely, specialized organisms that are capable of degrading resistant carbon polymers and have permanent or perennial mycelium; ephemeral fungi which flare into activity when easily absorbed carbon becomes available; and, mycorrhizal fungi which depend upon the photosynthates of their host. Nutritionally, it is unlikely that *E. cryptum* could belong in category one. Neither, can we envision it in category two since it would be adversely affected by competition from more efficient rhizosphere or soil-inhabiting deuteromycetes if it grew as slowly in nature as it does in culture. This leaves the third category and the possibility that *E. cryptum* is mycorrhizal or consistantly associates with the roots of one or more of the forest plants.

At present, no teleomorphic member of the Eurotiales is regularly found on roots or known to be mycorrhizal. However, Trappe (28) feels the latter is certainly probable and initially regarded *Elaphomyces*, an ectomycorrhizal hypogeous ascomycete, as belonging here prior to erecting a separate order for it (29).

Certain lines of evidence give credence to our view of a root rather than a soil existence for *E. cryptum*. First, the restricted carbon nutrition of *E. cryptum* is identical to many mycorrhizal fungi that in culture often show a preference for simple sugars and an inability to degrade di and polysaccharides (5, 12, 17). This pattern is very different from the one demonstrated by the common "soil" penicillia that can degrade a variety of macromolecules

(11). Dr. D. Malloch reports (personal communication) that many of their root isolates can deaminate amino acids and use them for energy; a trait shared by *E. cryptum*. Second, previous studies have shown that anamorphs (8, 9, 32) and rarely teleomorphs (9) of eurotiaceous fungi can be isolated from living surface-sterilized or washed root fragments. Although often dismissed as soil-introduced contaminants, there is no evidence excluding them from actually having grown in or on the roots from which they were obtained. Dr. R. Summerbell (Malloch, personal communication) regularly has isolated penicillia from 20-times-washed roots. He found that some of these stimulated the growth of black spruce in flask culture, even when mycorrhizal fungi were absent, although they did not themselves form mycorrhizae. Third, the appearance of certain root-invading ascomycetes *in vitro* is very similar to what we have observed in cultures of *E. cryptum*. For example, Danielson (6) found that certain isolates of E-strain fungi grow very slowly in culture, develop arachnoid margins, light brown pigmentation and exhibit as they age, a diversity of colony characteristics. Finally, evidence is slowly accumulating that ascomycetes previously thought to be strictly saprophytic, such as the carbonicolous discomycete *Sphaerosporella brunnea* (Alb. & Schw.:Fr) Svrek & Kubicka (7), are in reality mycorrhizal. While the evidence pointing to a root-inhabiting existence for *E. cryptum* is only circumstantial, such an environment ensures, as Marx (19) has pointed out for mycorrhizal fungi, that the essential simple sugars it requires are available for which it need exert only minimal competitive efforts.

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A MONOGRAPH OF THE GENUS ALEURINA MASSEE (= JAFNEADELPHUS RIFAI)

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ABSTRACT

According to the International Code of Botanical Nomenclature, *Aleurina* Massee (Ascodesmidoideae) is the correct generic name for *Jafneadelphus* Rifai. In this monographic study of the genus *Aleurina*, ten species have been accepted: *A. argentina, A. asperula, A. calospora, A. echinata, A. ferruginea, A. imaii, A. olivaceofusca,* and *A. subvirescens* are new combinations; two new species, one from the United States, the other from New Zealand, are named *A. americana* and *A. magnicellula*. A new genus, *Eoaleurina,* is erected based on *Jafneadelphus foliicola*. *J. tectipus* is transferred to the genus *Aleuria* Fuckel. A related fungus is described as *Smardaea protea* n. sp.

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INTRODUCTION

The genus *Aleurina* Massee, a member of Ascodesmidoideae, Pyronemataceae (Korf, 1972, 1973), includes a group of operculate Discomycetes which grow mostly on sandy or mossy soil, more rarely on rotten wood, leaves or duff. The first collection was made in Victoria, Australia in 1887, and reported as *Rhizina ferruginea* Phill. in Cooke (Cooke, 1888). The species in this genus, distributed world-wide, usually possess discoid, sessile, brownish, pustulate apothecia and marked ascospores. Ten species are accepted here.

Four species, *Aleurina argentina, A. asperula, A. calospora* and *A. ferruginea,* are found in Australia (Rifai, 1968), and more than one third of the total number of known *Aleurina* specimens were collected in the same country. Asia is also rich in *Aleurina* collections, even though *A. imaii* is the only species appearing in that geographical area. It has been commonly collected in China and Japan since Korf first reported this fungus from Japan (Korf, 1960; Korf & Zhuang, 1985). *A. argentina* and *A. echinata* occur mainly in South America (Gamundí, 1964, 1972; Pfister, 1984; Rifai, 1968). *A. olivaceofusca* and *A. subvirescens* are present in Europe (Svrček & Moravec, 1973; Svrček, 1977). Several collections, one from Indiana, in the United States, and the others from New Zealand, are treated here as two new species.

Certain species and combinations have been added to *Jafneadelphus* and more specimens have become available since Rifai (1968) described the genus. A review of the genus is necessary. *Aleurina* Massee turns out to be the correct generic name for this group of fungi, and is a name which has not recently been used in this sense. Our generic concept of *Aleurina* is basically identical with Rifai's delimitation of *Jafneadelphus.*

MATERIALS AND METHODS

All species were studied from herbarium specimens. A portion of a dry apothecium was surface wetted by a drop or two of 95% ethanol, then soaked in distilled water for 5 to 10 minutes, depending on the size of the material. All or a portion of a fully rehydrated apothecium was placed on the stage of a freezing microtome, embedded in a drop of 50% aqueous mucilage, and sectioned at 25 µm, cutting from the base of apothecium towards the hymenium. Examinations were carried out in Melzer's Reagent or in Soluble Blue 706 in lactic acid.

The gross morphology reported for each species is based on our own observations on every available specimen of the species and on the original description. All type specimens were reexamined. The terms used to describe the microanatomy of the fungi follow the definitions of Korf

(1952, 1973). The thickness of the ectal excipulum excludes the pustules on the receptacle. The spore sizes reported do not include the markings. The size of markings on the spores referred to in this paper were observed on fully mature spores.

Drawings were made from holotypes, except for those specially noted, and with the aid of a drawing tube. Photographs of the excipular structure were taken mostly from holotypes in Soluble Blue mounts using a Zeiss microscope equipped with a camera.

Ornamentations of ascospores were observed in the scanning electron microscope by cutting a tiny piece of hymenium from a fully mature apothecium of a dry herbarium specimen, placing this on a stub, coating with Gold-Palladium in a Balzers Union Sputter Coater, and examining in an AMR-1000A Scanning Electron Microscope at a voltage of 10 KV (Harmaja, 1976).

Abbreviations of literature citations are based on Botanico - Periodicum - Huntianum (Lawrence, et al., 1968).

HISTORY AND NOMENCLATURE

Aleurina tasmanica Massee was validly published in June, 1898. When Massee described the species, the name *Aleurina* was used without any generic diagnosis. It was, however, the first time that *Aleurina* was used at generic rank, and only one species was involved (Massee, 1898). According to Article 42 of the International Code of Botanical Nomenclature (ICBN) (Voss, et al., 1983), we must adopt *Aleurina* Mass. as a legitimate name of a monotypic genus, and the type species of the genus is Massee's *Aleurina tasmanica*.

Ten years earlier than *Aleurina tasmanica* Mass. appeared, Cooke published a species, *Rhizina ferruginea* Phill. in Cooke (Cooke, 1888). It is totally different from the type of the genus *Rhizina* Fr. In his studies of Australasian Discomycetes, Rifai (1968) found that *A. tasmanica* and *R. ferruginea* were synonyms. The two type specimens were also examined in our study. We fully agree with Rifai that they are conspecific. The oldest specific epithet should be chosen, and the correct name for this species is *Aleurina ferruginea* (Phill. in Cooke) comb. nov.

Rifai had discussed the nomenclatural situation when he erected his new genus *Jafneadelphus* Rifai. He noticed that "*Aleurina tasmanica* Mass. (June, 1898) was probably described before the name *Aleurina*(Sacc.) Sacc. was validly published as a genus." He treated *Aleurina* Mass. as a doubtfully published generic name and did not accept it (Rifai, 1968).

We suspect that the reason Rifai did not use *Aleurina* Massee as a legitimate generic name was probably based on his view of the 1966 ICBN. Article 42 of the 1966 ICBN reads: "A description or diagnosis of a new species assigned to a monotypic new genus is treated also as a generic description or diagnosis if the genus is not separately defined." It was not very clear, at that time, what "a description of a new species assigned to a monotypic new genus" meant. The wording of Art. 42 in the 1983 ICBN makes it very clear that the genus *Aleurina* Mass. was established simultaneously when the only species, *A. tasmanica* Mass., was validly published. Two months later, Saccardo (Aug. 30, 1898) published a new name, "*Aleurina* Sacc. '77," but we have been unable to trace this name to any 1877 publication by Saccardo. Possibly he was referring to his treatment (Saccardo, 1884), where the name *Phaeopezia* subg. *Aleurina* had been proposed with the monotype, *Phaeopezia retiderma* (Cooke) Sacc. Four years later, Saccardo and Sydow (in Saccardo, 1902) formally raised the subgenus to generic rank. We must treat *Aleurina* (Sacc.) Sacc. & Syd. as a later homonym of *Aleurina* Mass. Seaver (1913, 1928) adopted this incorrect use of *Aleurina*, but today the species he treated are generally placed in *Peziza* (Eckblad, 1968; Korf, 1972).

Jafneadelphus Rifai, typified by *Rhizina ferruginea*, was established to accommodate a small group of fungi which commonly occur on sandy soil or on duff. The generic delimitation was well-executed and four species were included (Rifai,1968). In the following years, *Jafneadelphus* was used by many mycologists: six taxa were added (Brummelen,1969; Gamundí, 1972; Reid, et al., 1981; Svrček, 1977; Svrček & Moravec, 1973), but the name *Aleurina* Mass. was either totally forgotten or considered to be an illegitimate name. The generic concept of *Jafneadelphus* Rifai is identical with the original description of *Aleurina* Mass. (Massee, 1898; Rifai, 1968). Since *Aleurina tasmanica*, the type of *Aleurina* Mass., is conspecific with *Rhizina ferruginea*, the type of *Jafneadelphus* Rifai, and the generic name *Aleurina* is much older than *Jafneadelphus*, *Aleurina* Mass. must be taken up and substituted for *Jafneadelphus* Rifai.

GENERIC DIAGNOSIS

Aleurina Massee, Bull. Misc. Inform. 1898:131, June, 1898 (monotypus: *A. tasmanica* Massee) [**non** *Aleurina* "(Sacc. '77)" [?(Sacc., 1884)] Sacc., Tab. Comp. Gen. Fung. Omn. p.30, August 30, 1898, Syll. Fung. 14:30, August 20, 1899, nomen dubium; **nec** *Aleurina* Sacc. in P. Hennings, Monsunia 1:35, 1900 (monotypus: *A. substipitata* P. Henn. & E. Nym.); **nec** *Aleurina* (Sacc., ut *Phaeopezia* subg. *Aleurina*, 1884) Sacc. & Syd., Syll. Fung. 16:738, 1902 (monotypus: *Peziza retiderma* Cooke)].

= *Jafneadelphus* Rifai, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Sect. 57(3):81, 1968 (holotypus: *Rhizina ferruginea* Phill. in Cooke).

Apothecium solitary to gregarious, turbinate to deep cupulate when young, discoid to flat at maturity, cupulate to deep cupulate when dry; sessile to subsessile; medium sized. **Hymenium** olivaceous, olivaceous brown, brown, or purplish brown when fresh; olivaceous brown, dark brown or dark purplish brown when dry. **Receptacle** brown to reddish brown when fresh, dark brown to dark purplish brown when dry, usually with pustules at the flanks near the margin, and with subhyaline, flexuous hyphae at the base, basal hyphae often enmenshing soil particles. **Ectal excipulum** of textura angularis, cells light brown, isodiametric to elongated polygonal, axes of cells usually perpendicular to the outer surface of apothecium, walls somewhat rigid, cells of the pustules brown, subglobose, thick- walled; **medullary excipulum** of textura intricata, hyphae subhyaline to pale brown, running more or less parallel to the outer surface; **subhymenium** well-developed or indistinguishable. **Asci** cylindrical, 4- or 8-spored, J- in Melzer's Reagent, usually with crozier at base. **Ascospores** ellipsoid, hyaline to pale yellow, with rounded warts, conical warts, or spines on surface, mostly biguttulate, uniseriate, fairly thick-walled when young, walls becoming thinner at maturity. **Paraphyses** simple, subcylindrical, subclavate to subcapitate at apex, with brownish pigment, septate in lower portion, in some species with a strongly cyanophilic paraphysis cap which soon loosens and either remains inverted cupulate or becomes reflexed and discoid, remaining attached to the paraphysis apex only at its center.

On sandy or mossy soil, leaves, wood, or duff.

KEY TO THE SPECIES OF ALEURINA

1. Spore markings rounded 2
1'. Spore markings other shapes 9
    2. Spores broadly ellipsoid, spore markings up to 5.7 µm in diam .... **A. calospora**
    2'. Spores ellipsoid, spore markings never up to 5.0 µm in diam 3
3. Pustules on receptacle if present of only one to two cell layers 4
3'. Pustules on receptacle well-developed 5
    4. Spores biguttulate, without an refractive area, paraphyses with a dark cap in Soluble Blue .... **A. olivaceofusca**
    4'. Spores with several guttules or spumose, with a refractive area, paraphyses without a dark cap in Soluble Blue .... **A. subvirescens**
5. Spore markings larger than 1.0 µm in diam 6
5'. Spore markings equal to or less than 1.0 µm in diam 8
    6. Cells of ectal excipulum 44-80 µm long, cell walls rigid, relatively thick, common in New Zealand .... **A. magnicellula**

6'. Cells of ectal excipulum less than 50 µm long, cell walls not rigid, relatively thin 7

7. Spores mostly 20.5-23.5 X 10.0-12.5 µm, spore markings up to 4.0 or 4.5 µm in diam, relatively stable in size on a single spore surface, known only from China, Japan .... **A. imaii**

7'. Spores mostly 23-26 X 12.5-14.0 µm, spore markings up to 3.0 or 3.5 µm in diam, variable in size on a single spore surface, known only from Australia .... **A. ferruginea**

8. Spores mostly 18-21 µm long, spore markings 0.3-0.7 µm in diam, usually interconnected, paraphyses subcylindrical .... **A. americana**

8'. Spores mostly 20-24 µm long, spore markings up to 1.0 um in diam, not connected, paraphyses subclavate .... **A. asperula**

9. Spore markings spine-like, spores 23.1-28.7 µm long ...... **A. echinata**

9'. Spore markings conical, spores 17.5-23.5 µm long .... **A. argentina**

In distinguishing species of the genus *Aleurina,* the ectal excipulum and ascospore characters are considered to be important. The sizes and shapes of excipular cells usually vary from one species to another, and the color and rigidity of cell walls show distinctions to a certain degree. The shapes and sizes of the spores and spore ornamentations are useful criteria. The SEM study of ascospores shows that there may be two kinds of membranes which cover the spore surface, one thin and smooth (Figs. 11, 16, 17), the other thicker and slightly coarse (Figs. 13, 18). Rifai (1968) had emphasized in his paper that "since the specific delimitation in the genus *Jafniadelphus* has been based largely on ascospores, fully mature specimens are essential for a satisfactory identification of its species." Our studies indicate that the spore ornamentations in some species may be larger and fused together when the spores are young; the markings condense, become smaller and individualized at maturity (Fig. 31). In other species, they appear to be smaller at first and larger when mature.

ACCEPTED SPECIES

Aleurina americana Zhuang & Korf, **sp. nov.** (Figs. 1, 11, 21)

Ab A. asperula pustulis eis in superficie receptaculi locatis humilioribus, cellulis excipularibus majoribus, ascosporis minoribus et ascosporarum notis minoribus, et paraphysium apicibus subcylindricis differens.

Apothecium discoid to cupulate, sessile, 2-3 mm in diam when dry, hymenium greenish yellow to olivaceous brown when dry, receptacle surface brown when dry, with brown pustules. **Ectal excipulum** of textura angularis, 110-120 µm thick, margin thinner, not extended towards outside, cells polygonally isodiametric, ovoid or elongated, axes of cells perpendicular to the outer surface, light brown to brown, 30-50 µm in diam; pustules low, cells of pustules ovoid, brown, 7-9 X 12-15 µm; basal hyphae abundant, hyaline to subhyaline, 3.0-5.0 µm wide. **Medullary excipulum** of textura intricata, ca. 120 µm thick at flanks and at base, 55-70 µm thick near margin, hyphae pale brown, 3.5-4.5 µm wide, more or less parallel to the outer surface. **Subhymenium** of textura intricata, ca. 10-15 µm thick, sometimes difficult to distinguish. **Asci** 8-spored, cylindrical, J- in Melzer's Reagent, with crozier at base, 240-260 X 11.7-15.0 µm. **Ascospores** uniseriate, ellipsoid, uni- to biguttulate, or with more than two guttules, very thick-walled when young, 14.6-22.0 X 8.0-12.2 µm; spore markings hemispherical, 0.3-0.7 µm in diam, up to 0.3 µm high, sometimes interconnected. **Paraphyses** subcylindrical, 4.0-5.0 µm wide at apex, not exceeding asci.

On wood.

Holotype: Green Bluffs, near Spencer, Owen County, Indiana, USA, R.L. Shaffer, 22. VIII. 1970, CUP 50872.

Notes: The closest species to *A. americana* in this genus is *A. asperula*. The American species differs from the Australian one in the low pustules, the smaller ascospores, the smaller spore markings, the arrangement of the spore markings, and the subcylindrical paraphyses. Among the many Austrialian collections examined we did not find any similar material. We treat the American fungus as a distinct species.

Aleurina argentina (Rifai) Korf & Zhuang, **comb. nov.** (Figs. 2, 12, 22)
≡ *Jafneadelphus argentinus* Rifai, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Sect. 57(3):89, figs. 68, 72, 1968.
= *Jafnea tasmanica* (Massee) Gamundí var. *singeri* Gamundí, Darwiniana 13: 584, pl. 2, figs. 8-14, 1964.

Apothecium discoid to cupulate at maturity, deep cupulate when young, sessile, 4-11(-23) mm in diam when dry, receptacle surface brown, dark brown, or dark purple brown when dry, with brown pustules. **Ectal excipulum** of textura angularis, 95-170 µm thick excluding pustules, cells polygonally ellipsoid to subspherical, axes of cells perpendicular to the outer surface, light brown, 10-35 µm long; cells of pustules spherical to ellipsoid, brown, 9-22 µm in diam, in a moniliform arrangement in marginal pustules; basal hyphae present at very base, pale brown, 3.7-6.5 µm wide. **Medullary excipulum** of textura intricata, 80-120 µm thick, hyphae subhyaline to pale brown, 3-4.5(-8.0) µm wide. **Subhymenium** indistinguishable. **Asci** 8-spored, cylindrical, J- in Melzer's Reagent, with crozier at base, 285-305(-360) X

(10.0-)14.6-17.0 µm. **Ascospores** uniseriate, ellipsoid, mostly biguttulate, 17.5-23.5(-24.2) X 10.0-13.8 µm, spore markings irregularly conical, or more rarely consisting of irregular warts (up to 3.5 µm in diam), subhyaline. **Paraphyses** subcapitate, 6.0-8.5 µm wide at apex, 3.8-4.5 µm below, not exceeding asci.

On sandy or mossy soil, soil with duff, or wood.

Specimens examined: ARGENTINA: on sandy soil, P.N. Nahuel Huapi : L. Moreno, I. Gamundí, 8. II. 1958, BAFC 20043 (paratype of *Jafnea tasmanica* var. *singeri*), CUP 61742 (ex BAFC 20043); on sandy soil, P.N. Nahuel Huapi : camino de L. Correntoso a L. Espejo, sobre ruta 8, I. Gamundí, 11. II. 1958, BAFC 20032 (holotype of *J. tasmanica* var. *singeri*), CUP 61743 (isotype of *J. tasmanica* var. *singeri*); on wood, P.N. Nahuel Huapi : L. Frias, canino a P. de las Nubes, C. Pujals - I. Gamundí, 24. IV. 1958, BAFC 20247 (paratype of *J. tasmanica* var. *singeri*); on sand, P.N. Nahuel Huapi : L. Gutierrez : Zo. Pilmayquen, C. Pujals - I. Gamundí, 28. IV. 1958, BAFC 20322 (paratype of *J. tasmanica* var. *singeri*); on sandy soil, Tierra del Fuego, Ushuaia, I. Gamundí 17. II. 1961, BAFC 21074; on mossy soil, Tierra del Fuego, L. Escondido, Ref. Vialidad, I. Gamundí, 25.II.1961, BAFC 20910; on mossy soil, Tierra del Fuego, L. Escondido E., I. Gamundí, 26. II. 1961, BAFC 21060; on soil with duff, T. del Fuego, Ushuaia, I. Gamundí - Merk, 18. I. 1964, BAFC 21702 (holotype of *Aleurina argentina*), CUP 61686 (isotype of *Aleurina argentina*); on soil, T. del Fuego, alrededores de Ushuaia, Rio Grande, I. Gamundí, 18. I. 1964, BAFC 21684; on wood, T. del Fuego, cabecera E. Lago Fagnano, Hassel - Gamundí, 10. II. 1965, BAFC 21979; on sandy soil with duff, T. del Fuego, T. Mayor, ladera S. sierra Alvear, arriba, Gamundí - Hassel, 12. II. 1965, BAFC 21867; on mossy soil and duff, Tierra del Fuego, Norte de Ushuaia, A. Giaiotti 7, 12. III. 1975, FH; on mossy soil and duff, Tierra del Fuego, Lapataia, N. E. Lago Roca, Gamundí - Giaiotti - Horak 28, 14. III. 1975, FH (LPS 385 ff), CUP 61684.

AUSTRALIA: on dead wood, Cascades, Hobart, Tasmania, L. Rodway, VII. 1921, HO 89945, CUP 61749.

CHILE: on duff, Punta Arenas, R. Thaxter, II. 1906, (no specimen number), FH; on duff, Punta Arenas, R. Thaxter, 20. II. 1906, "Hypogaeous #5", FH.

Notes: This species was first described as *Jafnea tasmanica* (Massee) Gamundí var. *singeri* Gamundí. The specific name was based on Massee's *Aleurina tasmanica,* and the fungus was accepted at the varietal level by Gamundí (1964). When *Jafneadelphus* Rifai was erected, Rifai did not accept *Aleurina* Massee as a validly published generic name, and accordingly he treated Gamundí's variety as a lower rank of an invalidly published specific name. Since the morphology of the fungus is distinct enough to be a taxon at the specific level, he designated a new type for the fungus and named it as *Jafneadelphus argentinus* Rifai (1968). As we have mentioned earlier, we accept the genus *Aleurina* Mass. as validly published, and thus Gamundí's variety is nomenclaturally legitimate. But we agree with Rifai that the shape of spore markings, the shape of paraphyses, and the arrangement of cells of pustules are different from any other species in the genus. We transfer it to the genus *Aleurina* at specific rank. The asci of one of the paratypes of *Jafnea tasmanica* var. *singeri,* BAFC 30332, turned strongly blue in Melzer's Reagent. It is a species in the Pezizaceae (two apothecia are left in the packet). Two of the specimens examined, G.-G.-H. 28 and "Hypogaeous #5," possess larger spore markings, and are not typical *A. argentina,* but they are not distinct enough to warrent description as another taxon. This species was illustrated again by Gamundí (1972).

Aleurina asperula (Rifai) Korf & Zhuang, **comb. nov.** (Figs. 3, 13, 23)
≡ *Jafneadelphus asperulus* Rifai, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Sect. 57(3):91, figs. 73-75, 1968.
= *J. asperulus* var. *tetraspermus* Rifai, ibid. 57(3):93, figs. 76,77, 1968.

Apothecium discoid, sessile to subsessile, 2-12 mm in diam when dry, hymenium dark brown, dull brown or other shades of brown when dry, receptacle surface brown to dark brown when dry, with brown pustules. **Ectal excipulum** of textura angularis, 75-220 µm thick, margin thick, extended towards the outside up to 350 µm, cells light brown, polygonally isodiametric to ellipsoid, 15-45 µm in diam, or up to 70 µm long, axes of cells perpendicular to the outer surface; cells of pustules subspherical, brown, 10-20 µm in diam; basal hyphae subhyaline, flexuous, 3.7-6.0 µm wide. **Medullary excipulum** of textura intricata, 70-330 µm thick, hyphae subhyaline, 3.0-6.5 µm wide, somewhat parallel to the outer surface. **Subhymenium** of textura intricata to textura epidermoidea, 37-50 µm thick. **Asci** mostly 8-spored, a few 4-spored, sometimes both 4- and 8-spored present in a single apothecium, cylindrical, J- in Melzer's Reagent, with crozier at base, 225-340 X (11-)14-18 µm. **Ascospores** uniseriate, ellipsoid, biguttulate, thick-walled when young, 18.3-27.0 X 9.5-14.6 µm; spore markings hemispherical or higher, mostly less than 1.0 µm in diam. **Paraphyses** subclavate, 4.5-9.5(-11.0) µm wide at apex, 2.7-4.5 µm below, equal to, slightly exceeding, or exceeding asci 10-15 µm.

On sand or sandy soil.

Specimens examined: AUSTRALIA: on ground, Bellerive, Tasmania, L. Rodway, VIII. 1921, HO 89951; on soil, Cheltenham, Victoria, L. Rodway, VIII. 1923, HO 89949, CUP 61747; on ground, Waterworks, Hobart, Tasmania, L. Rodway, 6. X. 1923, HO 89948, CUP 61746; on sandy and mossy soil, (no location), L. Rodway, (no date), HO 89952; on soil, Delamere S.E., J.H. Warcup, 2. VII. 1952, Wari 2115, K (paratype of *J. asperulus* var. *tetraspermus*); on sandy soil in scrub, Meningie, South Australia, L.D.

Williams, 7. VIII. 1954, Wari 3916, K (holotype of *A. asperula*); on sandy soil, Meningie, South Autralia, L.D. Williams, VII. 1956, Wari 7511, K (holotype of *J. asperulus* var. *tetraspermus*); on sandy ground amidst moss, Meningie, South Australia, L.D. Williams, VIII. 1956, Wari 7523, K (paratype of *A. asperula*); terrestrial under *Eugenia smithii*, Lilly-pilly Gully, Wilsons Promontory, Victoria, Neville Green, G. Beaton EO 476, VII. 1962, CUP 61672; on sand, off Moria-Anglesea Road, G. Beaton 151, 4. VIII. 1963, K, CUP 61678 (paratype of *A. asperula*); on sandy soil, junction Distillery Creek and Anglesea - Bambra road, G. Beaton 133b, 11. VIII. 1963, CUP 61673; on soil, McEachern's Cave area, Lower Glenelg, Victoria, A.C. Beauglehole & J.H. Willis, 11. VII. 1964, G. Beaton EO 357, CUP 61674; on sandy ground, Lower Glenelg National Park, Western Victoria, A.C. Beauglehole, 27. VI. 1964, G. Beaton 204 (part), K (paratype of *A. asperula*), CUP 61675 (ex G. Beaton 204); on soil, on side of unidentified road near Yea, Victoria, G.A. Crichton, 12. X. 1966, G. Beaton EO 195a, CUP 61676; on burnt over ground under *Eucalyptus*, about 7 miles from Carlisle on Colac Road, G. Beaton, 1. IX. 1968, Korf & Gruff Disc. Exsc. 64; on recently burnt ground, near mouth of Aire River, Otway Range, Victoria, G. Beaton EO 476a, 17. IX. 1977, CUP 61677.

Notes: Four specimens from Australia, labeled *Peziza brunneo-atra*, are misidentifications (the asci of the true *Peziza brunneo-atra* are positive in iodine rection). They are *A. asperula*. Rifai established two varieties and indicated that the only difference between them is 4 spores or 8 spores per ascus (Rifai, 1968). Among the specimens we examined, including the holotype and a paratype of *J. asperulus* var. *tetraspermus*, a collection may have some apothecia with 4-spored asci, and other apothecia with 8-spored asci; furthermore, a single apothecium may possess both 4-spored and 8-spored asci. We think that spore number in a single ascus of this fungus is not a sufficiently stable character to distinguish varieties, and the two varieties should be merged. *A. americana* is close to this species, but they can be separated by the differences of spore size, size and distribution of spore markings, pustule shape, and paraphysis shape. In a few cases, the spore marking size of *A. asperula* may be up to 1.5 µm in diam, but if so, only very few markings on a single spore surface are large.

Aleurina calospora (Rifai) Korf & Zhuang, **comb. nov.** (Figs. 4, 14, 24)
= *Jafneadelphus calosporus* Rifai, Verh. Kon. Ned. Adad. Wetensch., Afd. Natuurk., Tweede Sect. 57(3):82, figs. 62-64, 1968.

Apothecium discoid to cup-shaped, sessile, up to 6-13 mm in diam when dry, margin somewhat crenate, hymenium dark brown, dark purple brown to nearly black when dry, receptacle surface dark rusty to purple brown, with brown or dark brown pustules. **Ectal excipulum** of textura angularis, 160-210 µm thick, margin thick, up to 470 µm extended towards outside, cells light brown to brown, polygonally ellipsoid, up to 75 µm long, axes of cells perpendicular to outer surface; cells of pustules dark brown, subspherical, 15-35 µm in diam; basal hyphae hyaline to subhyline, 3.0-7.5 µm in diam. **Medullary excipulum** of textura intricata, 60-120 µm thick, hyphae pale brown, 3.7-5.7 µm wide. **Subhymenium** of textura intricata to textura epidermoidea, from indistinguishable to 40 µm thick (up to 100 µm according to Rifai). **Asci** 8-spored, cylindrical, J- in Melzer's Reagent, with crozier at base, 325-420 X 14-26 µm. **Ascospores** uniseriate, ellipsoid, biguttulate, thick-walled when young, 20.0-26.4 X 12.4-18.3 µm; spore markings subhyaline to pale brown, wart-shaped, up to 5.7 µm in diam, 3.7 µm high. **Paraphyses** subclavate, subhyline to brown, 6.0-8.5 µm at apex, 4.0-5.7 below, equal to or somewhat longer than asci.

On soil.

Specimens examined: AUSTRALIA: on soil, McRobies Gully, L. Rodway, X. 1917, HO 89955, CUP 61682; on the ground, Gaveat-Molesworth Road, near Alexandra, G.A. Crichton, 16. IX. 1963, G. Beaton 235, K (holotype).

NEW ZEALAND: on bank, Maungapohatu Tr., 12 km S.E. Ruatahuna, Urewera National Park, Gisborne, G. J. Samuels and P. R. Johnston, 2. XI. 1982, PDD 49722, CUP 61767.

Notes: The broad spore shape and the large markings on the spore surface distinguish this fungus from any other species of *Aleurina*. When Rifai erected the species, only the holotype, G. Beaton 235, was available. In this study we examined two other collections, HO 89955 which was labeled *Aleurina tasmanica* and PDD 49722. The ascospores of HO 89955 are not hyaline but subhyaline, the spore markings are subhyaline to pale brown, and all tissues are darker than those of the type specimen when seen in section. But the structure, spore shape and marking size are perfect matches for *A. calospora*. According to Rifai (1968), the medullary excipulum is poorly-developed, less than 60 µm thick, and the subhymenium is well-developed, up to 100 µm thick. Our examination of both type and HO 89955 shows, however, that the medullary excipulum is 85-120 µm thick, while the subhymenium varies from indistinguishable to 40 µm thick. The ascospores of PDD 49722 are up to 26.4 µm long and 18.3 µm wide, but the shapes of spore and spore markings are correct for this species. Based on the three specimens examined, we have emended slightly the original description of *A. calospora*.

Aleurina echinata (Gamundi) Korf & Zhuang, **comb. nov.** (Figs. 5, 15, 25)

≡ *Jafneadelphus echinatus* Gamundi, Trans. Brit. Mycol. Soc. 58:173, fig. 1, 1972.

Apothecium discoid to cup-shaped, sessile, 2-10(-16) mm in diam when dry, margin split and crenate, hymenium purplish brown when fresh, dark purplish brown when dry, receptacle surface dark brown with a tinge of red when fresh, purplish brown to blackish brown when dry, with pustules. **Ectal excipulum** of textura angularis, 190-350 µm thick, cells polygonally ellipsoid, axes of cells perpendicular to the outer surface, 30-75 µm long; cells of pustules brown, subspherical, 17-25 µm in diam; basal hyphae pale brown to subhyaline, thin-walled, 4.0-9.5 µm wide. **Medullary excipulum** of textura intricata, 65-110 µm thick, hyphae light brown, 1.6-4.5 µm wide, densely interwoven. **Subhymenium** of textura intricata to textura epidermoidea, ca. 35-65 µm thick. **Asci** 8-spored, cylindrical, J- in Melzer's Reagent, crozier not seen, 300-385 X 18.7-24.0 µm. **Ascospores** uniseriate, ellipsoid, uni- to biguttulate, thick-walled when young, 23.1-28.7 X 13.7-17.6 µm; spore markings spine-like, or rod-shaped with a narrow and blunt apex, with polygonal base, 1.6-4.4 µm high, sometimes with a few tiny protrusions on the apex of the spine. **Paraphyses** subcapitate, 5.0-7.3 µm at apex, 4.4 µm below, not or slightly exceeding asci.

On sandy and mossy soil.

Specimens examined: ARGENTINA: on soil between mosses, in *Nothofagus* forest, Tierra del Fuego, Lapataia, R. Schuster & I. Gamundí, 22. II. 1961, BAFC 20856 (holotype), CUP 61685 (isotype); on mossy soil, Tierra del Fuego, Lago Roca (E), I. Gamundí, 22. II. 1961, BAFC 20887, CUP 61741; on mossy and sandy soil, Tierra del Fuego, E. del Lago Roca, I. Gamundí 30, 18. II. 1974, FH (LPS 401 ff); on duff, Tierra del Fuego, N. del Ushuaia, E. Horak 1, 12. III. 1974, FH.

CHILE: (slide no substrate), Punta Arenas, R. Thaxter, 1905-06, "Hypogaeous #14", FH; on duff and soil, Punta Arenas, R. Thaxter, 7. III. 1906, (no specimen number), FH.

Notes: This species is distinguished from *A. argentina* in the much larger spore size, and the high, spine-like spore markings. It is a well-delimited species in *Aleurina*. When the name was given, only the holotype was available. Pfister (1984) reported that R. Thaxter had collected this species from Chile in the early 1900's.

Aleurina ferruginea (Phill. in Cooke) Zhuang & Korf, **comb. nov.** (Figs. 6, 16, 26)

≡ *Rhizina ferruginea* Phill. in Cooke, Grevillea 16:74, 1888.

≡ *Jafneadelphus ferrugineus* (Phill. in Cooke) Rifai, Verh. Kon. Ned. Adad. Wetensch., Afd. Natuurk., Tweede Sect. 57(3):85, figs. 65, 66, 69, 70, 1968.

= *Aleurina tasmanica* Massee, Bull. Misc. Inform. 1898:131, 1898.

≡ *Jafnea tasmanica* (Massee) Gamundí, p.p. typica, Darwiniana 13: 584, 1964.

Apothecium discoid to flat, sessile to subsessile, 20 mm or more in diam when fresh, 6-17 mm in diam when dry, hymenium yellowish brown, rusty brown, olivaceous brown to dark brown when fresh, yellowish brown, dark brown to dark olivaceous brown when dry, receptacle surface rusty brown when fresh, brown when dry, with pustules. **Ectal excipulum** of textura angularis, 75-210 µm thick, margin mostly not or slightly thicker than ectal excipulum, cells pale brown to brown, polygonally isodiametric to ellipsoid, axes of cells perpendicular to the outer surface, 17-40 µm in diam, up to 50 µm long; cells of pustules brown to dark brown, 9-21 µm in diam; basal hyphae abundant, scattered from flanks to base, subhyaline, undulate, 3.7-6.0 µm wide. **Medullary excipulum** of textura intricata, 120-600 (-1000) µm thick, hyphae subhyaline to pale brown, 2.5-9.0 µm wide, more or less parallel to the outer surface. **Subhymenium** of textura angularis to textura epidermoidea, 30-65(-100) µm thick. **Asci** 8-spored, cylindrical, J- in Melzer's Reagent, with crozier at base, 250-360 X 14-21 µm. **Ascospores** uniseriate, ellipsoid, biguttulate, 21.8-31.5 X 11.0-14.8 (-16.0) µm; spore markings hemispherical or slightly higher, up to 3.5 µm in diam, mostly 1.5-2.5 µm in diam, up to 2.5 µm high. **Paraphyses** subcylindrical to subclavate, usually with a dark blue cap in Soluble Blue (Fig. 6c), 5.1-7.0 µm at apex, 3.0-4.5 µm below, usually not exceeding asci.

On sandy soil or duff.

Specimens examined: AUSTRALIA: on decayed fragments of wood on the ground, Mordialloc, Victoria, C. French, VIII. 1887, K (holotype of *A. ferruginea*); on naked ground, Horsham, Doncaster, Victoria, (no collector), X. 1889, Doncaster 476, K; on the ground, Hobart, Tasmania, L. Rodway 128, 16. IX. 1894, K, (holotype of *Aleurina tasmanica* and *Aleurina* Massee), HO 89944, CUP-D 2769, CUP 61696 (isotype of *Aleurina tasmanica* and *Aleurina* Mass.); on ground, Cascades, Hobart, Tasmania, L. Rodway, VIII. 1918, HO 89987; on sandy soil, Cascades, Hobart, Tasmania, L. Rodway, VIII. 1919, HO 89959, CUP 61751; on sandy soil, Cascades, Hobart, Tasmania, L. Rodway, VII. 1920, HO 89958, CUP 61753; on ground, Cascades, Hobart, Tasmania, L. Rodway, VII. 1921, HO 89956, CUP 61754; on ground, Cascades, Hobart, Tasmania, L. Rodway, V. 1924, HO 89957, CUP 61752; on sand, Bellerive, Tasmania, L. Rodway, VIII. 1924, HO 89960, CUP 61748; on ground, (no location), L. Rodway, (no date), HO 89953; on soil and duff, forest area, Aboriginal Reserve, Framlingham, Victoria, G. Beaton 238, 9. VIII. 1964, K; terrestrial under mixed *Eucalyptus*, Forest Reserve near Framlingham, Victoria, Katrine & G. Beaton, 8. VIII. 1964, CUP 61679 (= G. Beaton 238 according to Mr. G. Beaton); on sandy road side, Fraser National Park near Eildon, Victoria, Katrine & G. Beaton, 15. IX. 1973, G. Beaton EO 012, CUP 61680; on ground under *Pseudotsuga*, Plantation road, Narbethong, Victoria, B. Fuhrer & G. Beaton, 1. VII. 1974, G. Beaton EO 012a, CUP 61681.

Notes: When Rifai published the genus *Jafneadelphus,* he included two subspecies, ssp. *ferrugineus* and ssp. *imaii,* in *J. ferrugineus.* Even though he noticed that the shorter-spored and larger-warted Japanese collections differ from Australian collections, he concluded that these characteristics were not significant enough to treat the taxa at specific rank, but as subspecies (Rifai, 1968). Our recent studies are based upon 14 Australian and 18 Asian collections. Careful comparison has been made between the geographically different collections. The spore markings of the Australian specimens may be up to 3.0 or 3.5 µm in diam, but they vary from very small to large on a single spore surface; those of the Asian ones can be up to 4.0 or 4.5 µm in diam and are relatively stable in marking size on a single spore surface. The spore size of Australian materials is 21.8-31.5 X 11.0-15.0 µm, mostly around 23-26 X 12.5-14.0 µm, whereas the spore size of the Asian ones is 18.3-26.0 X 9.1-13.8 µm, mostly around 20.5-23.5 X 10.0-12.5 µm; the cells of ectal excipulum are slightly larger, and the basal hyphae are numerous from flanks to base in Australian collections. Generally, the excipula of apothecia in Australian materials are thicker than those from Asia. As far as we know, the Asian taxon does not appear in Australia, and the Australian taxon has never been found in Asia. We treat them at specific rank.

Aleurina imaii (Korf) Zhuang & Korf, **comb. nov.** (Figs. 7, 17, 27)

■ *Jafnea imaii* Korf, Nagaoa 7:7, figs. 1, 4, 7, 1960.

■ *Jafneadelphus ferrugineus* (Phill. in Cooke) Rifai subsp. *imaii* (Korf) Rifai, Verh. Kon. Ned. Adad. Wetensch., Afd. Naturk., Tweede Sect. 57 (3):90, fig. 71, 1968.

Apothecium discoid at maturity, turbinate to cupulate when young, subsessile, 10-15 mm when fresh, 3-8 mm when dry, hymenium olive-green to brownish green when fresh, yellowish brown, brown to dark brown when dry, receptacle surface light reddish brown to drab greenish brown when fresh, brown to dark brown when dry, with pustules. **Ectal excipulum** of textura angularis, 70-190 µm thick, margin 150-200 µm or thicker, extended towards the outside, cells light brown to subhyaline, polygonally subspherical to elongated, axes of cells perpendicular to the outer surface, 11-38 µm in diam, or up to 50 µm long; cells of pustules light brown to brown , 11-25 µm in diam; basal hyphae subhyaline, 4.0-6.7 µm wide. **Medullary excipulum** of textura intricata, 110-375 µm thick, hyphae pale brown to subhyaline, 3.0-8.2 µm wide, more or less parallel to outer surface. **Subhymenium** of textura intricata to textura epidermoidea, 45-70 µm thick. **Asci** 8-spored, cylindrical, J- in Melzer's Reagent, with crozier at base, 240-366 X 12.9-19.3(-21.4) µm. **Ascospores** uniseriate, ellipsoid, biguttulate, thick-walled when young, 18.3-26.0 X 9.1-13.8 µm; spore markings wart-shaped up to 4.5 µm in diam, mostly ca. 3.0 µm in diam, up to 3.0 µm high. **Paraphyses** subcylindrical to slightly swollen at apex, 3.0-5.0(-6.5) µm at apex, ca. 4.5 µm below, usually with a dark blue cap in Soluble Blue (Fig. 7c), not exceeding asci.

On mossy or bare soil, and duff.

Specimens examined: CHINA: on soil, between Jianfugong and Tianshidong, Qingchengshan, Guan Xian, Sichuan, R.-y. Zheng & R.P. Korf, 16 IX. 1981, CUP-CH 2323, 2333, 2351; on ground among mosses, between Fangningqiao and Zushidian, Qingchengshan, Guan Xian, Sichuan, R.-y. Zheng & R.P. Korf, 17. IX. 1981, CUP-CH 2372; on mossy soil, between Chaoxiting and Zhuangguantai, Qingchengshan, Guan Xian, Sichuan, R.-y. Zheng & R.P. Korf, 18. IX. 1981, CUP-CH 2403; on soil, Qingchengshan, Sichuan, W.-y. Zhuang, 5. VII. 1983, HMAS 45039, 45040, 45041, 45042; on wood, Qingchengshan, Sichuan, W.-y. Zhuang, 7. VII. 1983, HMAS 45043.

JAPAN: on soil and duff, Jakko, Nikko, Tochigi Pref., Honshu, Y. Kobayasi, 27. IX. 1940, CUP-JA 1499, RPK 59-238; on mossy duff, west end of Lake Chuzenji, Nikko Nat. Park, Tochigi Pref., Honshu, S. Imai, R.P. Korf et al., 5. X. 1957, CUP-JA 61; on duff, between Kiyomizo Temple and Maruyama Park, Kyoto, Honshu, S. Imai, M. Hamada, T. Hongo, & R.P. Korf, 23. X. 1957, CUP-JA 184 (holotype), Korf & Gruff Disc. Exs. 65 (isotype); on bare soil and stones on stream bank, Miidera, Otsu, Shiga Pref., Honshu, S. Imai, T. Hongo, & R.P. Korf, 24. X. 1957, CUP-JA 221; on cliff in shade, Yonezawa Yamagata Prefecture, D. Shimizu, CUP-JA 3731 (Korf & Shimizu 5); on soil, Mt. Kiyosumi, Chiba Pref., Honshu, Imai, Kobayasi, Shimizu, Ashima, Tubaki, & Korf, 15. VI. 1958, CUP-JA 1035; on mossy soil, between Kiyomizu Temple and Maruyama Park, Kyoto, Honshu, M. Hamada, T. Hongo, Y. Shidei, Y. Doi, & R.P. Korf, 4. XI. 1963, CUP-JA 2808; on duff, Asegata, Chuzurji-koban, Okku-Nikko, Tochigi Pref. Honshu, IMC3 Mycology People, 25. VIII. 1983, CUP-JA 3687.

Notes: This species was originally published as *Jafnea imaii* by Korf (1960). It was later synonymized with *Jafnea tasmanica* (Gamundi, 1964), and treated as *Jafneadelphus ferrugineus* ssp. *imaii* (Rifai, 1968). When Rifai reduced the species to the subspecies rank, only one Japanese collection was examined. Based on the 18 available collections from both Japan and China, we think that it is a well-delimited species, and that the closest species in the genus is *A. ferruginea*. The development of spores and spore markings has been observed in this fungus. The spores are hyaline and very thick-walled at first, later becoming larger, with small, cyanophlic particles within the spore cytoplasm (Figs. 31a, b). Cyanophilic materials appear gradually around the spores, and the walls become thinner when the spores are still young (Fig. 31c). At a certain point, the cyanophilic layer reaches its thickest stage, and begins to differentiate into warts (Fig. 31d). The warts are large and fused together at the beginning, smaller and discrete at maturity (Figs. 31e, f).

Aleurina magnicellula Dissing, Korf & Zhuang, **sp. nov.** (Figs. 8, 18. 28)

Ab A. ferruginea cellulis excipularibus majoribus et parietes crassiores praebentibus, asci basi angustiore et magis elongata, et ascosporarum notis majoribus differens.

Apothecium discoid, sessile, up to 5-15 mm in diam when dry, hymenium olivaceous to brown when fresh, brown to dark olivaceous brown when dry, receptacle surface light brown to brown when fresh, dark brown when dry, with pustules. **Ectal excipulum** of textura angularis, 120-260 µm thick, margin thicker, extended towards the outside up to 350 µm, cells brownish, polygonally isodiametric to ellipsoid, cell walls rigid and more or less thickened, 44-70(-83) X 25-44 µm, axes of cells perpendicular to the outer surface; cells of pustules subspherical, brown, 14-26 µm in diam; basal hyphae pale brown to subhyaline, 4.5-7.5 µm wide. **Medullary excipulum** of textura intricata, about 400 um thick (up to 3 mm thick according H. Dissing), hyphae pale brown, 5.0-10.0 µm wide, more or less parallel to the outer surface. **Subhymenium** of textura intricata, 50-130 µm thick. **Asci** 8-spored, cylindrical, sometimes with a tapered base inserted deeply into the subhymenium, J- in Melzer's Reagent, with crozier at base, 360-410 X 14.0-19.0 µm. **Ascospores** uniseriate, ellipsoid, uniguttulate to biguttulate, 24.0-29.7 X 12.2-15.0 µm; spore markings usually higher than hemispherical, up to 4.0 µm in diam and 3.0 µm high. **Paraphyses** slightly enlarged at apex, 5.0-6.0 µm at apex, 4.0-4.5 µm below, with a dark blue cap in Soluble Blue (Fig. 8c), not exceeding asci.

On the ground.

Holotype: on the ground under *Leptospermum* scrub, Huntby West, NEW ZEALAND, E. P. White, 20. VII. 1969, F.412, C.

Paratypes: NEW ZEALAND: on ground, Sharp's Bush, Henderson Valley, Auckland, J. M. Dingley, V. 1970, PDD 29013; on soil, Waikoha Road, Huntly West, South Auckland, E. P. White, VI.1970, PDD 29014; on sandy soil, Forest Road, Puketi State Forest, South of Kaitaia, Hokianga County, Northland, G. J. Samuels and E. Horak, 13. V. 1981, PDD 44463, 49465; on soil, Anawhata Road, Waitakere ranges, Auckland, G. J. Samuels and P. R. Johnston, 9. VI. 1981, PDD 49488; on mossy soil, Urewera National Park, Gisborne, G. J. Samuels, 26. V. 1982, PDD 45507; on soil, Waitakere ranges, Auckland, G. J. Samuels, P. R. Johnston and R. H. Petersen, 3. VI. 1982, PDD 45644, CUP 61768; on soil under *Leptospermum* sp., University Tramping Club Hut, Swanson, Waitemata City, Auckland, G. J. Samuels, P. R. Johnston, and K. Haggerty, 24. VIII. 1982, PDD 44457.

Notes: This species differs from *A. ferruginea* in the much larger and thicker-walled cells of the ectal excipulum, the narrow and atypically shaped crozier at the ascus base, and the larger spore markings, and from *A. imaii* in the larger and thicker-walled cells of the ectal excipulum, the larger spore size, and the relatively smaller spore markings. The SEM study shows that the membrane which covers the ascospore surface of this species is relatively thick and coarse (Fig. 28).

Aleurina olivaceofusca (Svrček & Moravec) Zhuang & Korf, **comb. nov.** (Figs. 9, 19, 29)

= *Jafneadelphus olivaceofuscus* Svrček & Moravec, Česká Mykol. 27: 131, fig, 1973.

Apothecium discoid, sessile, 5-9(-12) mm in diam, hymenium olivaceous brown when fresh, dark brown when dry, receptacle surface brown when fresh, dark brown when dry, slightly downy. **Ectal excipulum** of textura angularis, 180-290 µm thick, thinner near margin, margin extended towards outside, cells brown in outer layers and light brown inside, polygonally isodiametric to ovoid, 30-80 µm in diam (95-125 X 70-80 µm according to the original authors); pustules if present very low, of only one or two cell layers, cells brown; basal hyphae abundant, subhyaline, flexuous, 4.0-9.0 µm wide. **Medullary excipulum** of textura intricata, 95-260 µm thick, hyphae subhyaline, 3.7-9.0 µm wide, some of them parallel to the outer surface. **Subhymenium** of textura intricata, ca. 20-35 µm thick. **Asci** 8-spored, cylindrical, J- in Melzer's Reagent, with crozier at base, 240-280 X 10.2-14.0 µm. **Ascospores** uniseriate, ellipsoid, biguttulate, very thick-walled when young, 13.5-19.8 X 7.5-10.3 µm; spore markings wart-shaped, 0.2-1.0(-1.8) µm in diam, 0.2-1.0 µm high, some connected or fused together especially at both ends of spores. **Paraphyses** subcylindrical, 3.0-5.0 µm wide, with a dark stained cap in Soluble Blue (Fig. 9c), not exceeding asci.

On the fallen rotten leaves of *Fagus sylvatica* and a trunk of *Acer pseudoplatanus*.

Specimen examined: CZECHOSLOVAKIA: on dead leaves of *Fagus sylvatica*, Moravia, Josefov prope Adamov, J. Moravec & M. Svrček, 24. IX. 1972, PRM 336568 (holotype).

Notes: The structure of apothecium fits *Aleurina* well except for the very low pustules on the receptale, consisting of only one or two layers of cells. It is distinct from *A. subvirescens* in the size, shape and guttulation of ascospores, the presence of very few large spore markings, and a dark stained cap on the top of paraphyses in Soluble Blue.

Aleurina subvirescens (Velen.) Zhuang & Korf, **comb. nov.** (Figs.10, 20, 30)

= *Humaria subvirescens* Velenovský, České Houby. p.855, 1922.

* *Jafneadelphus subvirescens* (Velen.) Svrček, Česká Mykol. 31:69, 1977.

Apothecium discoid, sessile, about 2 mm in diam when dry, hymenium brown or dark ochraceous brown when dry, receptacle surface brown, roughened. **Ectal excipulum** of textura angularis, 150-220 µm thick, cells brown to light brown, polygonally isodiametric to ovoid, axes of cells nearly perpendicular to outer surface, ca. 30-65 µm or more in diam; pustules if present of only one or two cell layers, cells brown, mostly ovoid, 9-35 µm long; basal hyphae present, pale brown, 4.0-5.5 µm wide. **Medullary excipulum** of textura intricata, 70-120 µm thick, hyphae pale brown to subhyaline, 4.5-6.0 µm wide. **Subhymenium** indistinguishable from medullary excipulum. **Asci** 8-spored, cylindrical, J- in Melzer's Reagent, crozier not seen, 200-270 X 14-16 µm. **Ascospores** uniseriate, ellipsoid, with blunt ends, spumose or with several guttules, with a central refractive area, slightly thick-walled when young, 19.0-23.5 X 10.0-14.6 µm; spore markings round to ellipsoid, 0.4-0.6 µm (up to 1.0 µm according to Svrček) in diam, some fused together. **Paraphyses** slightly enlarged at apex, ca. 4.0-6.0 µm at the widest part, not exceeding asci.

On duff.

Specimen examined: CZECHOSLOVAKIA: on duff, Bohemia centr., Struharov prope Mnichovice, in verrimentis marcidis inter muscos in pinetis vetustis, J. Velenovský, 25. IX. 1919, PRM 149462 (holotype).

Notes: The species was first published under *Humaria* by Velenovský (1922), transferred to *Jafneadelphus* and redescribed by Svrček (1977, 1979). After examining the type specimen, consisting of only a single apothecium, we found that this fungus differs from the typical *Aleurina* species in a few aspects: the ascospores are not biguttulate but multiguttulate, and each ascospore has an obviously unstained, somewhat refractive area when mounted in Soluble Blue 706 or in Phloxine. The excipular structure is almost the same as that of *A. olivaceofusca*. Since other characters of the species are acceptable for the genus *Aleurina*, and we cannot find a more suitable genus for it, we keep it in *Aleurina* until such time as more material from the type locality is available and more distinctions are found.

SPECIES IMPERFECTLY KNOWN

"*Peziza drummondii*" Berkeley, London J. Bot. 4:71, 1845.

Notes: This fungus might be a species of *Aleurina*, or a new genus as Rifai (1968) suggested. Rifai (1968) had listed "*Peziza drummondii*" in his key to the species of *Jafneadelphus*, and noted that "when young medullary excipulum gelatinous; receptacle irregularly folded or wrinkled; basal hyphae mostly minutely warted." The type specimen, Drummond 183, was reexamined. We find only one apothecium in the package, and it is young. The way in which the cells of ectal excipulum contact each other is looser than that in the typical *Aleurina*, and the medullary excipulum is more or less gelatinous. The ascospores are very young, seemingly with ornamentations which might be warts. It is certainly different from any other species of *Aleurina* previously described. We prefer neither to tranfer it nor to establish a new genus on the basis of an immature apothecium, but to describe what we have seen. We hope that this species can be collected again around the type locality.

Apothecium discoid, irregularly folded or wrinkled, sessile, hymenium brown when dry, receptacle bright brown when fresh (according to Berkeley) and brown when dry, with pustules, surface farinaceous. **Ectal excipulum** of textura globulosa to textura angularis, cells globose, light brown, 13-20 µm in diam, cells of pustules loosely in contact, basal hyphae hyaline, warted. **Medullary excipulum** of textura intricata, very thick, somewhat gelatinous, hyphae light brown to pale brown, tightly interwoven. **Asci** 8-spored, cylindrical, J- in Melzer's Reagent. **Ascospores** very young, only three nearly mature spores seen, measuring 24.0-24.2 X 13.2-14.0 µm. **Paraphyses** filiform, septate.

Specimen examined: AUSTRALIA: on ground, Swan River, J. Drummond, (no date), Drummond 183, K (holotype).

EXCLUDED SPECIES

1. *Jafneadelphus amethystinus* (Phill.) Brumm. Persoonia 5:225, figs. 1, 2, 3, 1969.
   - ≡ *Ascobolus amethystinus* Phill., Grevillea 4:84, 1875.
   - ≡ *Peziza phillipsii* Cooke, Mycographia. p.48, fig. 88, 1876 (nom. nov.).
   - ≡ *Humaria phillipsii* (Cooke) Sacc., Syll. Fung. 8:140, 1898.
   - ≡ *Galactinia phillipsii* (Cooke) Boud., Hist. Class. Discom. Eur. p. 49, 1907.
   - ≡ *Galactinia amethystina* (Phill.) Wakefield, Trans. Brit. Mycol. Soc. 6:375, 1920.
   - ≡ **Smardaea amethystina** (Phill.) Svrček, Česká Mykol. 23:91, fig. 4, 1969.

Notes: Dr. Dissing has kindly communicated his taxonomic opinion of this fungus. We agree with him that it is not a species of *Aleurina* (=*Jafneadelphus*), but of *Smardaea*, belonging to Ascodesmidoideae (Korf, 1972). Dissing (1985) has prepared a paper on a new species of this genus, *S. purpurea* Dissing.

When we studied the type of *Smardaea, S. amethystina*(Phill.) Svrček, we found that the spore ornamentations of the type specimen are different from those illustrated by Svrček when he published the genus (Svrček, 1969). One of the Svrček's specimens (PR 666709) has been borrowed and examined. Our observations indicate that the spore markings of the type of *Smardaea* are identical to what Brummelen (1969) and Dissing (1985) illustrated in their papars. Svrček's material is congeneric with *S. amethystina,* but not conspecific. A specimen of *S. purpurea* sent us by Dr. Dissing was also compared. PR 666709 differs from *S. purpurea* in the much shorter asci, the longer ascospores which lack de Bary bubbles, the variable, angular, and mostly discrete spore markings, and the wider paraphyses. A new taxon has to be established based on PR 666709 (see below).

The distinctions between *Greletia* and *Smardaea* remain questionable. We did not see much difference in the excipular structure between the two genera. We do notice that purple pigments are present in the apothecia of both. The type species of *Greletia* has smooth-walled, spherical ascospores (Donadini, 1980), while those of the type species of *Smardaea* are verrucose and ellipsoid. Donadini (1980) included both spherical- and ellipsoid-spored as well as verrucose-spored species in his original generic concept of *Greletia*.

The new species is described as follows:

Smardaea protea Zhuang & Korf, **sp. nov.** (Fig. 32)

Ab S. amethystina et S. purpurea ascosporarum ornamentibus variabilibus irregularibus vel angularibus, ascosporis longioribus, et paraphysibus latiusculis differens.

Apothecium cupulate to discoid, sessile, ca. 5 mm in diam when dry, hymenium very dark purple when dry, receptacle concolorous with hymenium, surface with small pustules. **Ectal excipulum** of textura angularis to textura globulosa, 35-50 µm thick excluding pustules, cells subspherical to ovoid, axes of cells perpendicular to the outer surface, with purple contents; pustules 24-40 µm high, cells of pustules subspherical to ovoid, 9-18 µm in diam, with purple contents. **Medullary excipulum** of textura intricata, 60-75 µm thick, light purple, hyphae tightly interwoven. **Subhymenium** of textura angularis to textura epidermoidea, 20-30 µm thick, light purple. **Asci** 8-spored, cylindrical, J- in Melzer's Reagent, ca. 200-230 X 13-15 µm (195-210 X 16-18 µm according to Svrček). **Ascospores** uniseriate, ellipsoid, biguttulate, 19.0-25.8(-30.0) X 9.0-12.4(-13.2) µm; spore markings angular to irregular in shape, varying in size, mostly less than 0.7 µm high. **Paraphyses** filiform, slightly enlarged at apex, up to 6.5 µm wide.

On sandy soil with duff.

Holotype: Roblín, na lesní cestě směrem k Solopiskům, ve staré smrčině na vlhčí písčitohlimté zemi řídce pokryté smrkovým jehličím, Čechy, Czechoslovakia, M. Svrček, 25. VII. 1948, PR 666709.

2. *Jafneadelphus foliicola* (P. Henn.) Spooner in Reid et al., Kew Bull. 35: 854, fig. 2, 1981.
   ≡ *Humaria foliicola* P. Henn., Hedwigia 41:29, 1902.

Notes: This is not a species of *Aleurina* Massee. It differs from *Aleurina* in apothecial tissues being slightly gelatinous, cells of ectal excipulum isodiametric, globose to angular, but not elongate polygonal-shaped, cell walls thin, hyaline and not rigid, pigmented particles present in the cytoplasm of ectal excipular cells and paraphyses, and the young asci dextrinoid in Melzer's Reagent. The other close genera are *Greletia* and *Smardaea*. It is similar to these genera in the presence of purple pigments in the tissues when fresh, and the structure of the ectal excipulum. But it differs from them in the tissues being slightly gelatinous, paraphyses with swollen apices, pigmented particles present in the cytoplasm of both ectal excipular cells and paraphyses, losing the purple tint in dry specimens, and the young asci dextrinoid in Melzer's Reagent. A common characteristic of the species of *Greletia* and *Smardaea* is the presence of purple color in the apothecial tissues when sections of a dry apothecium are observed in water mounts. This species shows a brown color instead. Since this species can hardly fit in any one of these three genera, a new genus is proposed and described.

EOALEURINA Korf & Zhuang, **gen. nov.**

Ab Aleurina Massee *cellulis excipuli ectalis isodiametricis, globosis vel angularibus, et non polygonaliter elongatis, parietibus cellularum exilibus et hyalinis, non rigidis et pigmentiferis differens. Ab Greletia* Donadini *et Smardaea* Svrček *contentu cellularum excipularium brunneo, non purpureo, in speciminibus siccatis in aqua ad examinationem paratis, et apicibus paraphysium tumidis differens. Ab his generibus trebus omnibus texturis apothecialibus parum gelatinosis, et excipulo medulloso ex permixtione texturae angularis et exturae intricatae potius quam tantum ex textura intricata non gelatina consistente differens.*

Apothecium discoid to subturbinate, sessile to subsessile, hymenium smooth, receptacle pustulate. **Excipular tissues** slightly gelatinous; ectal excipulum of textura globulosa to textura angularis, cells hyaline, thin-walled, pigmentation if present only in the cytoplasm; medullary excipulum of textura angularis mixed with textura intricata. **Subhymenium** indistinguishable. **Asci** operculate, 8-spored, subcylindrical, J- in Melzer's Reagent. **Ascospores** ellipsoid, biguttulate, with ornamentations on the surface.

Paraphyses swollen at apex, with pigmented contents.
Holotypus: *Humaria foliicola* P. Henn.

Eoaleurina foliicola (P. Henn.) Korf & Zhuang, **comb. nov.** (Fig. 33)
≡ *Humaria foliicola* P. Henn., Hedwigia 41:29, 1902.

Apothecium discoid to subturbinate, sessile to subsessile, 2-3 mm in diam when dry (when fresh 5-11 mm in diam according to P. Hennings, mostly 3.5 mm in diam according to Pfister's field notes); hymenium dark purple, dark vinaceous or brown when dry, lilac to purple when fresh (greyish-flesh colored, then yellowish according to P. Hennings); receptacle palid to pale purple when fresh, dark vinaceous when dry, with pustules. **Ectal excipulum** of textura globulosa to textura angularis, 65-85 µm thick, cells globose, hyaline and thin-walled, with pigmented particles in cytoplasm; margin lower than hymenium; cells of pustules 9-19 µm in diam; a few basal hyphae at very base, hyaline, 7-9 µm wide. **Medullary excipulum** of textura intricata to textura angularis mixed with textura intricata, 100-150 µm thick, hyphae hyaline. **Subhymenium** not easy to distinguish. **Asci** 8-spored, cylindrical, J- and young asci dextrinoid in Melzer's Reagent, 220-260 X 9.5-13.0 µm (230-260 X 16-20 µm according to P. Hennings), crozier not seen. **Ascospores** ellipsoid, biseriate when young and uniseriate at maturity, uni- to biguttulate, 14.6-17.6 X 7.0-8.0 µm (16-20 X 9-11 µm according to P. Hennings); spore markings wart-shaped, 1.3 µm in diam, ca. 0.5 µm high. **Paraphyses** swollen at apex, 4.0-7.5 µm at apex, 3.5-3.7 µm below, containing pigmented particles, equal to or slightly exceeding asci.

On unidentified leaves, leaves and petioles of *Cecropia,* duff, snail shells, rocks, twigs, etc.

Specimens examined: BRAZIL: on leaves, St. Catharina: Blumenau, Möller 722, 8. IX. 1892, S (holotype).

JAMAICA: on leaves and petioles of *Cecropia,* duff, snail shells, rocks, twigs, etc., R. P. Korf, J. R. Dixon, K. P. Dumont, R. W. Erb, D. H. Pfister, D. R. Reynolds, A. Y. Rossman & G. L. Samuels, 22. I. 1971, CUP-MJ 682.

3. *Jafneadelphus tectipus* Spooner in Reid, et al., Kew Bull. 35:852, fig. 1, 1981.
≡ **Aleuria tectipus** (Spoon. in Reid, et al.) Zhuang & Korf, **comb. nov.**

Notes: This is not a species of *Aleurina. Jafneadelphus tectipus* differs from all species of *Aleurina* in its pale yellow disc when fresh, smooth receptacle surface, hyaline, globose ectal exciplar cells, short, hyaline, thin-walled basal hyphae and special spore ornamentation. Spooner's original drawings have shown the shape of spore ornamentations. There are a few small cavities in the center of each polygonal-shaped marking. All above characteristics recall to us the members of *Aleuria* Fuckel. Spore markings of *Aleuria* other than reticulate have already been reported (Boudier, 1905-1911; Denison, 1963; Moravec, 1972). We transfer this species to *Aleuria* of the Aleurieae (Korf, 1972).

Specimen examined: ECUADOR: on soil, fern zone, Galapagos Islands, Santa Cruz, Media Luna, Evans & Cronshaw 25, 30. VII. 1976, K (holotype).

4. *Aleurina apiculata* (Cooke) Sacc. et Syd., Syll. Fung. 16:739, 1902.
   ≡ *Peziza apiculata* Cooke, Mycographia. p.175, 1877.

The correct placement for this species is in *Peziza*. Details have been provided by Donadini (1981), Häffner (1986), Hirsch (1984), Le Gal (1941), Moravec (1985), and Pfister (1979a).

5. *Aleurina applanata* (Rabenh. et Gonn.) Sacc. et Syd., Syll. Fung. 16:739, 1902.
   ≡ *Peziza applanata* Rabenh. et Gonn. Mycol. Eur. pl.6, f.5, 1869.

This is probably a species of the Pezizaceae. In his monographic studies of *Ascobolus* and *Saccobolus*, van Brummelen (1967) has discussed this fungus.

6. *Aleurina aquehongensis* Seaver, Mycologia 6:278, 1913.

Pfister (1979b) has reexamined the type and reported that the asci of this species have a positive iodine reaction and it is a true *Peziza*.

7. *Aleurina atra* Lloyd, Mycol. Writings 7:1235, 1923.

This is a fungus with smooth-walled ascospores and brown setae on the receptacle surface according to the original description.

8. *Aleurina atrovinosa* (Cooke) Seaver, N. Amer. Cup-Fungi. p.101, 1928.
   ≡ *Peziza atrovinosa* Cooke, Bull. Buffalo Soc. Nat. Sci. 2:288, 1875.

This is a true *Peziza*. Cooke's original name is correct. Donadini (1981), Pfister (1978), and Seaver (1928) provided descriptions. It has been confused with *Peziza ostracoderma* Korf by Dennis (1957), who was followed by various authors, as discussed by Hennebert and Korf (1975).

9. *Aleurina crinita* (Bull. : Fr.) Sacc. et Syd., Syll. Fung. 16:739, 1902.
   ≡ *Peziza crinita* Bull., Hist. Champ. France. p.249, 1791; Herb. France. pl. 416, f.2, 1789.

The apothecium of this species has a reddish hymenium and brown setae on the receptacle surface according to Cooke (1876-1879).

10. *Aleurina elastica* (Pat. et Gaill.) Sacc. et Syd., Syll. Fung. 16:739, 1902.

= *Phaeopezia elastica* Pat. et Gaill., Bull. Soc. Mycol. France 4:99, 1888.

The ascospores of this species are brown according to the original authors.

11. *Aleurina empetri* (Rostr.) Sacc. et D. Sacc., Syll. Fung. 18:90, 1906.

= *Pheaopezia empetri* Rostr., Bot. Tidsskr. 25:317, 1903.

According to the original author, this fungus has light brown ascospores.

12. *Aleurina fuscocarpa* (Ell. et Holw.) Sacc. et Syd., Syll. Fung. 16:739, 1902.

= *Peziza fuscocarpa* Ell. et Holw., J. Mycol. 1:5, 1885.

According to Durand (1922) and Seaver (1951), the correct name for this taxon is *Catinella nigroolivacea* (Schw.) Durand, an inoperculate discomycete.

13. *Aleurina lignicola* (Rostr.) Sacc. et Syd., Syll. Fung. 16:739, 1902.

= *Phaeopezia lignicola* Rostr. Meddel. Grønland 18:58, 1894.

This is probably an inoperculate discomycete with dark brown ascospores based on the original description.

14. *Aleurina lloydiana* Rehm, Ann. Mycol. 2:35, 1904.

This was listed by Seaver (1928) as a synonym of *Aleuria cestrica* (Ellis & Everh.) Seaver. According to the original description the ascospores are pigmented, and apiculate at both ends.

15. *Aleurina macracantha* Bánh., Borbasia 1:157, 1939.

According to the original description the asci of this species show a positive iodine reaction, and the fungus belongs in the Pezizaceae.

16. *Aleurina marchica* (Rehm) Sacc. et Syd., Syll. Fung. 16:739, 1902.

= *Humaria marchica* Rehm, in Rabenh. Krypt. - Fl. ed.2, 1(3)[Lief. 42]: 952, 1894.

This is *Catinella nigroolivacea* (Schw.) Durand, an inoperculate discomycete (Durand, 1922; Seaver, 1951).

17. *Aleurina nigrodisca* Sawada, Dept. Agric. Gov. Res. Inst. Formosa Rept. 51:30, 1931.

According to the original description and drawings, the ascospores of this fungus are very thick-walled when young, and dark brown at maturity. It grows on dung, and is probably a member of the Ascoboleae.

18. *Aleurina novae-terrae* (Ell. et Ev.) Sacc. et Syd., Syll. Fung. 16:738, 1902.

= *Phaeopezia novae-terrae* Ell. et Ev., Bull. Torrey Bot. Club 25:507, 1898.

An isotype of this species was examined. It is an operculate discomycete, and has J- asci, brown, smooth-walled ascospores, and hooked paraphyses.

Specimen examined: CANADA: on rotten wood, Newfoundland, Waghorne, 4. X. 1897, CUP-D 4262 (17-145).

19. *Aleurina ochracea* (Mass. et Rodw.) Sacc. et D. Sacc., Syll. Fung. 18:89, 1906.

= *Phaeopezia ochracea* Mass. et Rodw., Kew Bull. 1901:159, 1901.

This is a fungus with light brown and smooth-walled ascospores. We have not studied the type, and the species was not mentioned by Rifai (1968).

20. *Aleurina olivacea* (Pat.) Sacc. et Syd., Syll. Fung. 16:739, 1902.

= *Phaeopezia olivacea* Pat., Bull. Soc. Mycol. France 9:145, 1893.

According to the original description, the apothecium of this fungus is stipitate, and its ascospores are olivaceous black. It is possibly an inoperculate discomycete.

21. *Aleurina orientalis* (Pat.) Sacc. et Syd., Syll. Fung. 16:739, 1902.

= *Phaeopezia orientalis* Pat., (as '*Pheopezia*'), J. Bot. (Morot) 4:59. 1890.

The correct name for this species is *Ascobolus scatigenus* (Berk.) Brumm. (Brummelen, 1967).

22. *Aleurina pakistanica* Ahmad, Biologia 1:5, 1955.

This species has smoky brown, reticulate ascospores according to the original description.

23. *Aleurina phaeospora* (Hazsl.) Sacc. et Syd., Syll. Fung. 16:739, 1902.

= *Pyronema phaeosporum* Haszl., Verh. K. K. Zool.-Bot. Ges. Wien 37: 166, 1887.

The ascospores of this fungus are brown and smooth-walled according to the original description.

24. *Aleurina puiggarii* (Speg.) Sacc. et Syd., Syll. Fung. 16:739, 1902.

= *Peziza puiggarii* Speg., Anales Soc. Ci. Argent. 12:221, 1881.

Based on the original description, this is probably an inoperculate discomycete, and has olivaceous, unequal-sided ascospores.

25. *Aleurina readeri* Rehm, Ann. Mycol. 6:324, 1908.

According to the original description the apothecium is stipitate, and ascospores are smooth-walled.

26. *Aleurina reperta* (Boud.) Sacc. et Syd., Syll. Fung. 16:739, 1902.

≡ *Aleuria reperta* Boud., Bull. Soc. Mycol. France 10:64, 1894.

This is *Peziza apiculata* Cooke according to Hirsch (1984).

27. *Aleurina retiderma* (Cooke) Sacc. et Syd., Syll. Fung. 16:739, 1902.

≡ *Peziza retiderma* Cooke, Mycographia. p.176, 1877.

The correct placement is in *Peziza* (Eckblad, 1968; Rifai, 1968). It was superfluously recombined in *Aleurina* by Seaver (1913).

28. *Aleurina splendens* (Pat.) Sacc. et Syd., Syll. Fung. 16:740, 1902.

≡ *Phaeopezia splendens* Pat., Bull. Soc. Mycol. France 11:219, 1895.

According to the original description the ascospores are pigmented, smooth-walled.

29. *Aleurina stipitata* Rodw., Pap. & Proc. Roy. Soc. Tasmania 1924:117, 1925.

The fungus has a long-stipitate apothecium, and dark grey to nearly black, smooth-walled ascospores according to the original description.

30. *Aleurina stipitata* Cash, Stud. Nat. Hist. Iowa Univ. 17:219, 1937.

This is a later homonym of *A. stipitata* Rodw., based on a different type. Its apothecium is stipitate, and ascospores are brown, coarsely tuberculate. According to Pfister (1979b) this is a true *Peziza*, and closely related to *P. atrovinosa* Cooke and *P. retiderma* Cooke.

31. *Aleurina subapiculata* Höhn., Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Cl., Abt. I, 118:397, 1909.

According to v. Höhnel's original note, this fungus is very close to *A. apiculata*, which is a true *Peziza*.

32. *Aleurina substipitata* P. Henn. et E. Nym. in Henn., Monsunia 1:35, 1899.

This species has cinnamon-colored to dark brown ascospores, occuring on leaves and petioles, and the apothecia have branched, brown basal hyphae. We have not examined the type or any other specimens.

33. *Aleurina substipitata* P. Henn et E. Nym in Henn. var. *pleuropoda* Penz. et Sacc., Malpighia 15:212, 1902 ('1901').

According to the original description and drawings, the ascospores of this fungus have longitudinal stripes on the surface, and the species, on

Zingiberaceous leaves, is probably an *Ascobolus*.

34. *Aleurina tahitensis* (Pat.) Sacc. et Syd., Syll. Fung. 16:740, 1902.
≡ *Phaeopezia tahitensis* Pat., Bull. Soc. Mycol. France 12:135, 1896.

The apothecium of this species has long, dark hairs, and the ascospores are pale brown based on the original description.

35. *Aleurina vinacea* (Clem.) Sacc. et Syd., Syll. Fung. 16:740, 1902.
≡ *Pheaopezia vinacea* Clem., Bot. Survey Nebraska 4:16, 1896.

According to the original description, the asci of this fungus are positive in iodine reaction. This is a species in the Pezizaceae.

FIGURES

Fig. 1. *Aleurina americana*: a. ascospores, X1580; b. ascus base, X1000; c. paraphysis apices, X1000; holotype.
Fig. 2. *Aleurina argentina*: a. ascospores, X1580; b. ascus base, X1000; c. paraphysis apices, X1000; holotype.
Fig. 3. *Aleurina asperula*: a. ascospores, X1580; b. ascus base, X1000; c. paraphysis apices, X1000; holotype.
Fig. 4. *Aleurina calospora*: a. ascospores, X1580; b. ascus base, X1000; c. paraphysis apices, X1000; holotype (except a, left spore, HO 89955).
Fig. 5. *Aleurina echinata*: a. ascospores, X1580; b. ascus base, X1000; c. paraphysis apices, X1000; holotype.
Fig. 6. *Aleurina ferruginea*: a. ascospores, X1580; b. ascus base, X1000; c. paraphysis apices, X1000; holotype (except a, left spore, Beaton 238).
Fig. 7. *Aleurina imaii*: a. ascospores, X1580; b. ascus base, X1000; c. paraphysis apices, X1000; holotype.
Fig. 8. *Aleurina magnicellula*: a. ascospores, X1580; b. ascus bases, X1000; c. paraphysis apex, X1000; holotype.
Fig. 9. *Aleurina olivaceofusca*: a. ascospores, X1580; b. ascus bases, X1000; c. paraphysis apices, X1000; holotype.
Fig. 10. *Aleurina subvirescens*: a. ascospores, X1580; b. paraphysis apices, X1000; holotype.
Fig. 11. *Aleurina americana*: ectal excipulum, X220; holotype.
Fig. 12. *Aleurina argentina*: ectal excipulum, X220; holotype.
Fig. 13. *Aleurina asperula*: ectal excipulum, X220; holotype.
Fig. 14. *Aleurina calospora*: ectal excipulum, X220; HO 89955.
Fig. 15. *Aleurina echinata*: ectal excipulum, X220; holotype.
Fig. 16. *Aleurina ferruginea*: ectal excipulum, X220; holotype.

Fig. 17. *Aleurina imaii*: ectal excipulum, X220; holotype.

Fig. 18. *Aleurina magnicellula*: ectal excipulum, X220; holotype.

Fig. 19. *Aleurina olivaceofusca*: ectal excipulum, X220; holotype.

Fig. 20. *Aleurina subvirescens*: ectal excipulum, X220; holotype.

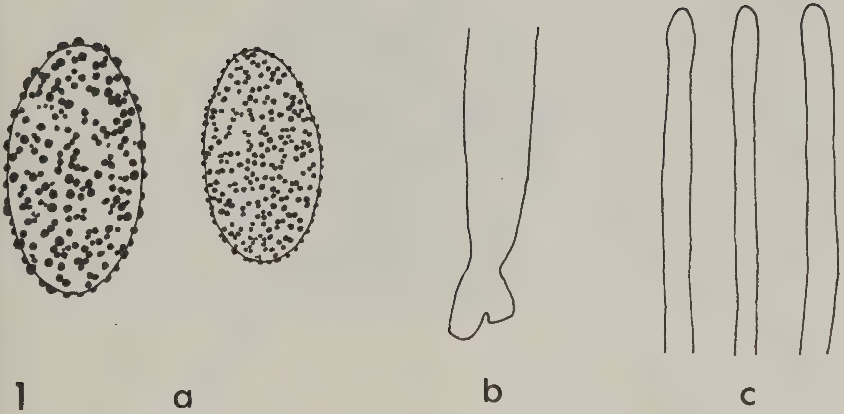
Fig. 21-30. SEM study of ascospores and spore markings: 21. *A. americana*; 22. *A. argentina*; 23. *A. asperula,* EO 476a; 24. *A. calospora,* HO 89955; 25. *A. echinata*; 26. *A. ferruginea*; 27. *A. imaii*; 28. *A. magnicellula*; 29. *A. olivaceofusca*; 30. *A. subvirescens*. All X3000, all holotypes except Figs. 23, 24.

Fig. 31. Development of ascospores and spore markings of *Aleurina imaii*: a. hyaline and thick-walled young spores; b. particles in cytoplasm; c. beginning of marking formation; d. a thick layer around spore walls; e. fused large warts; f. markings on mature spores; X735.

Fig. 32. *Smardaea protea*: a. paraphysis apices, X1000; b. ectal excipulum, X500; c. four ascospores, X1580; holotype.

Fig. 33. *Smardaea amethystina*: two ascospores, X1580; holotype.

Fig. 34. *Eoaleurina foliicola*: a. ascospore, X1580; b. paraphysis apex, and young and mature asci, X400; c. ectal excipulum, X400; CUP-MJ 682.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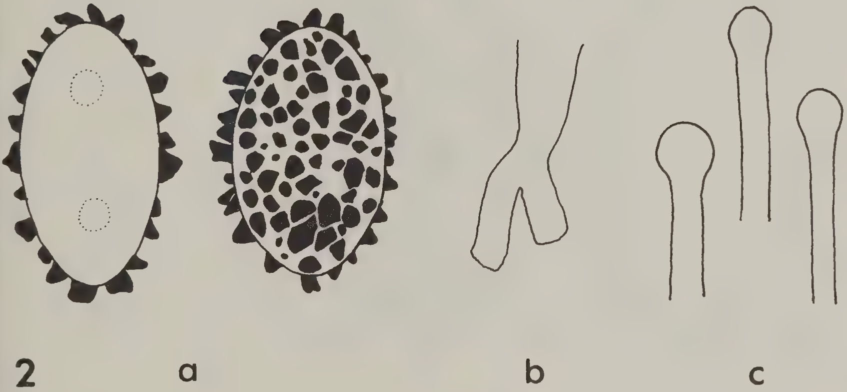
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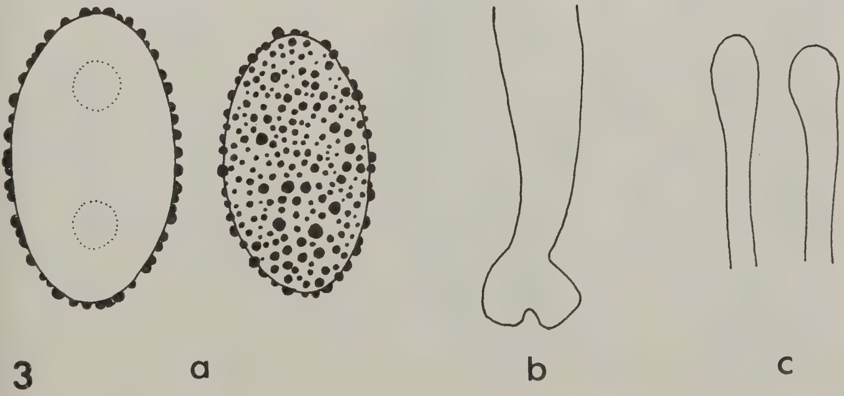
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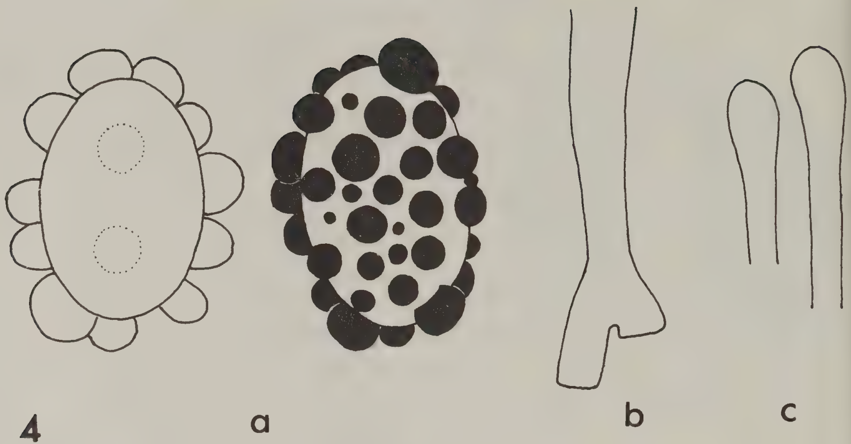
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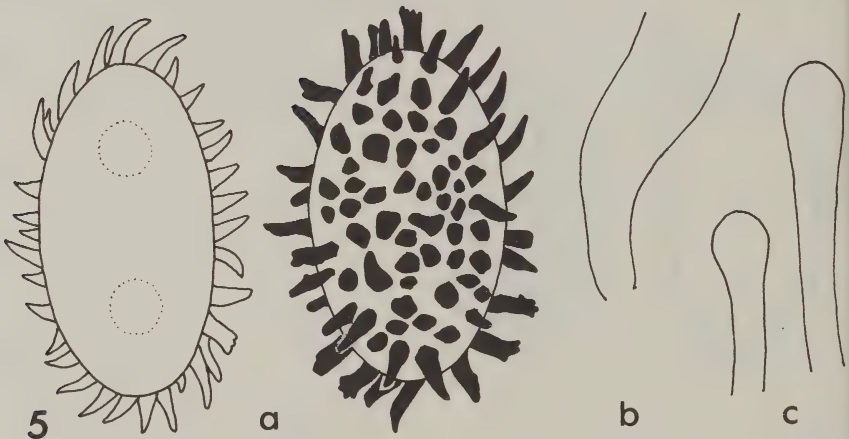
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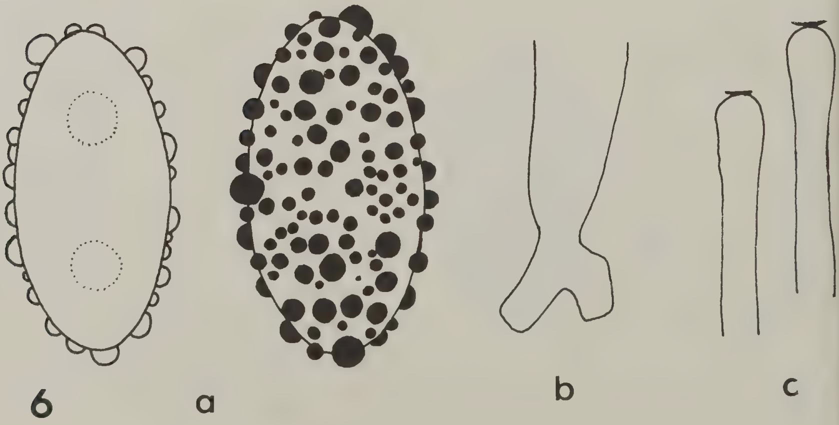
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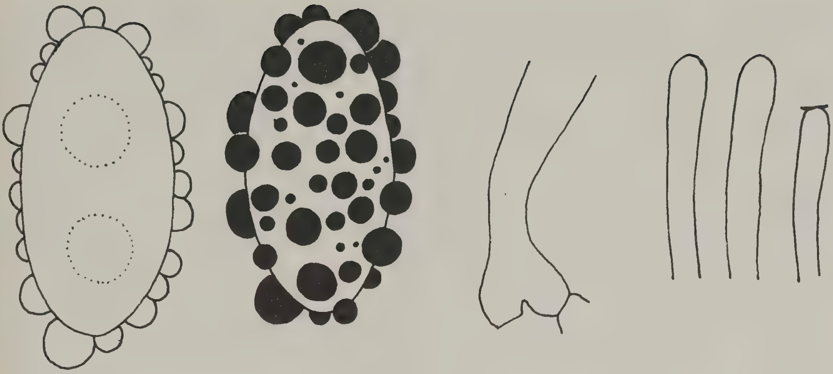

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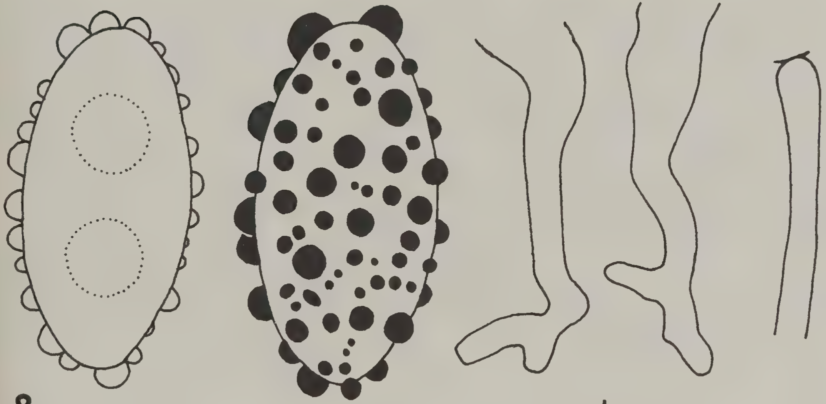

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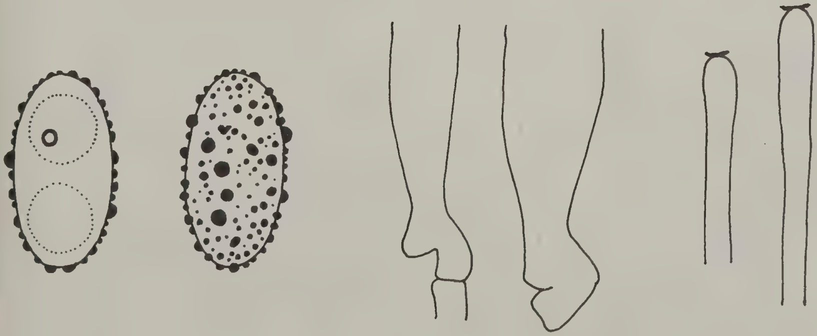

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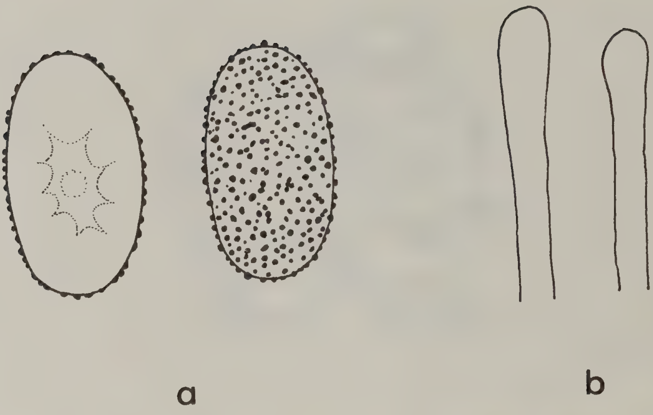

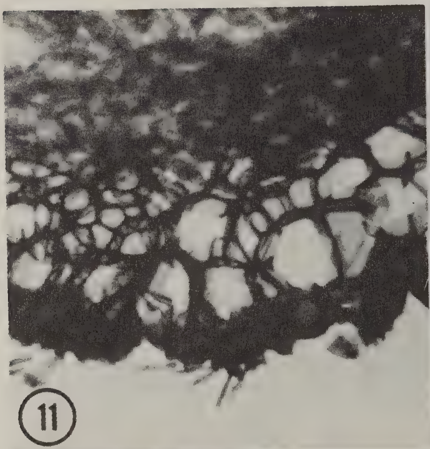
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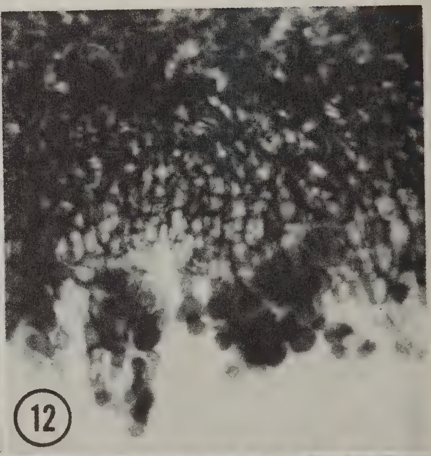
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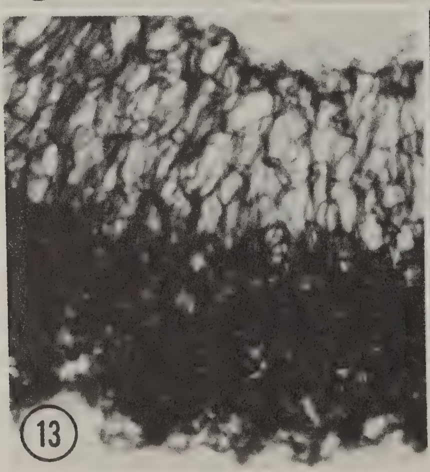
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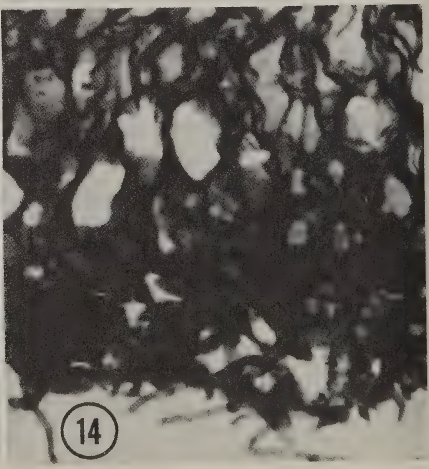
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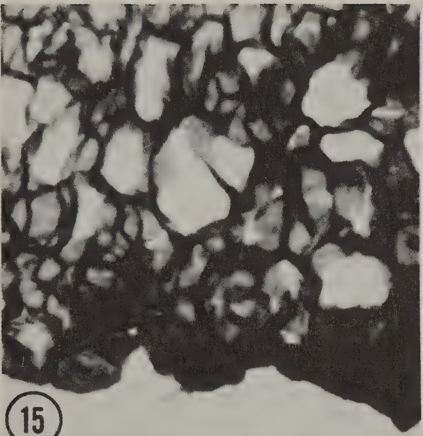
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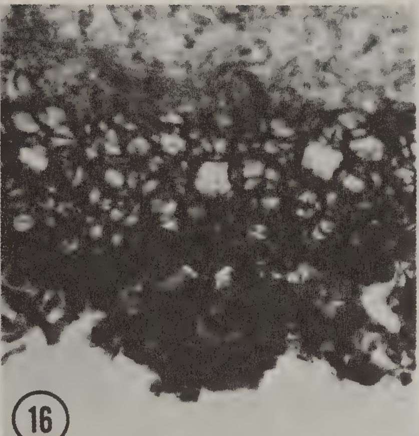
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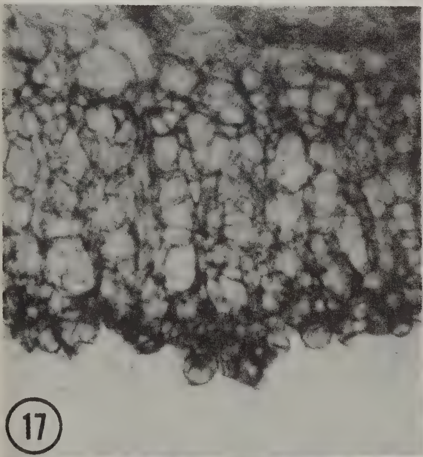
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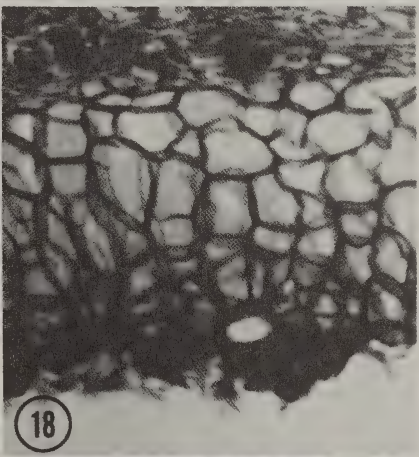
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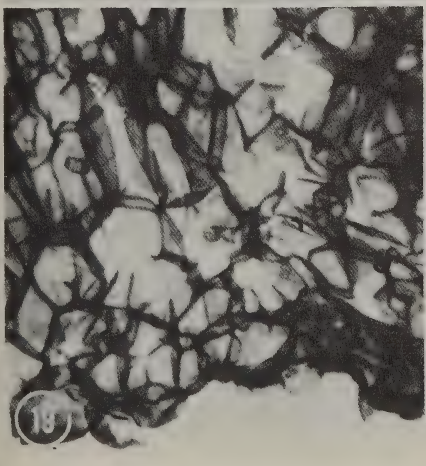
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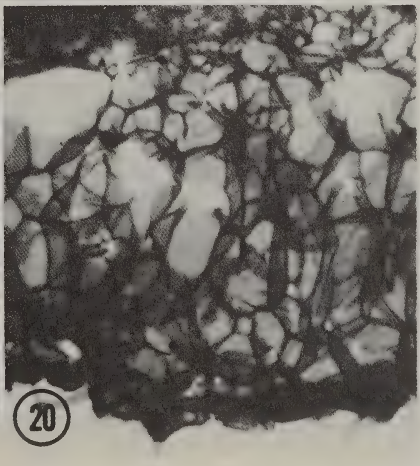
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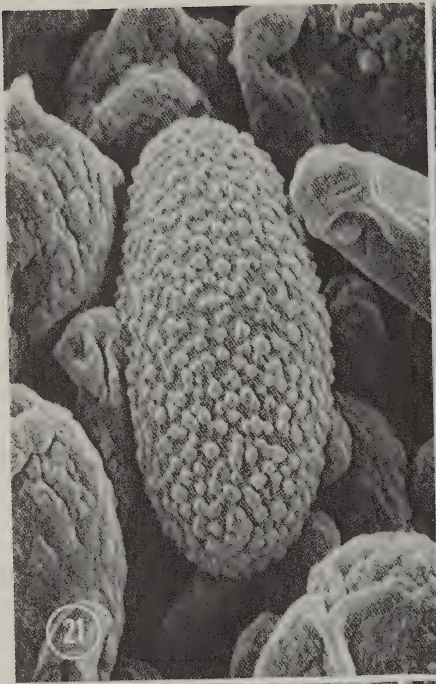
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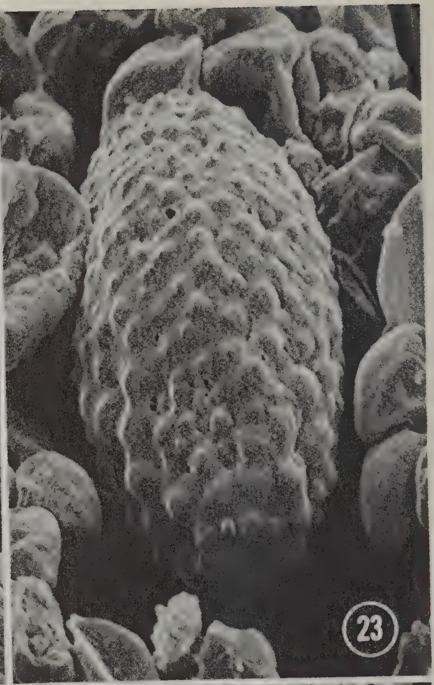
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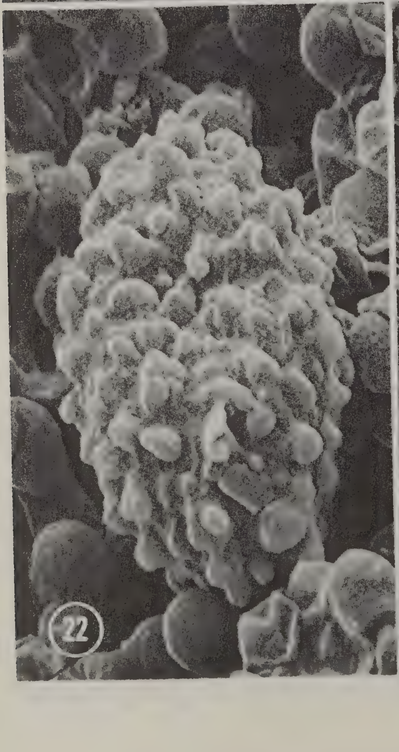
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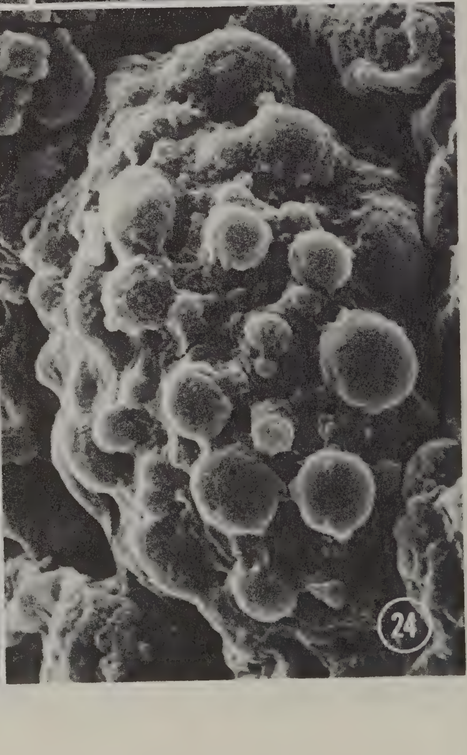
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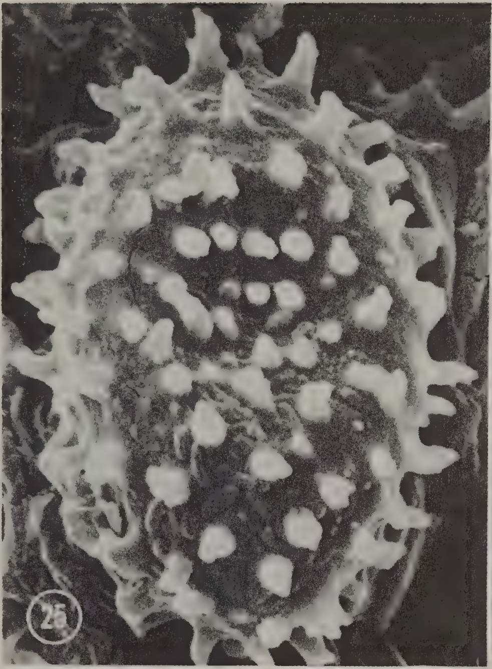
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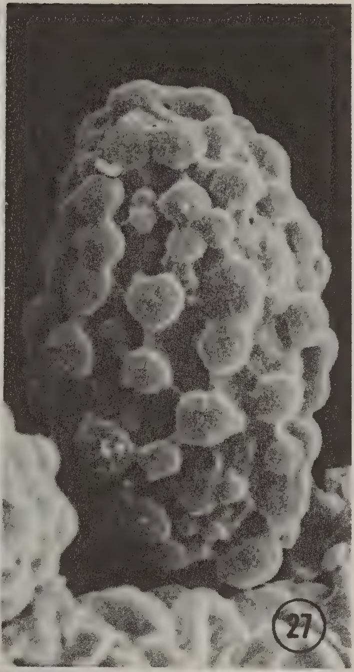
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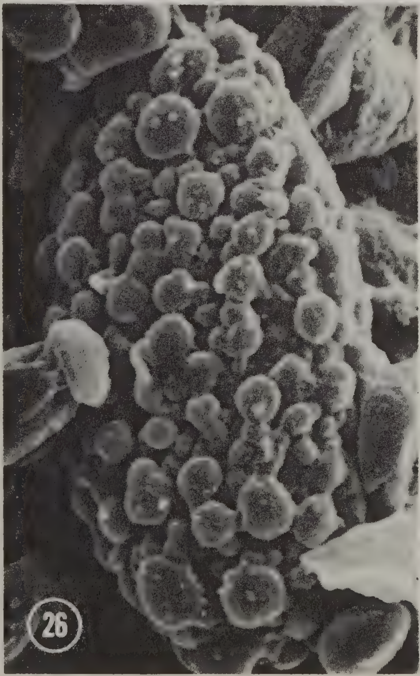
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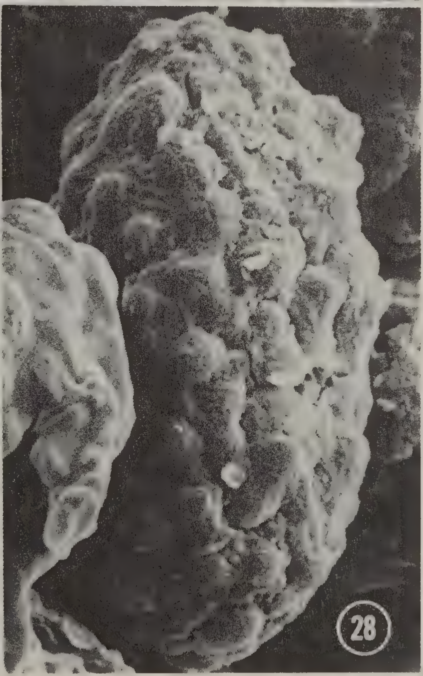
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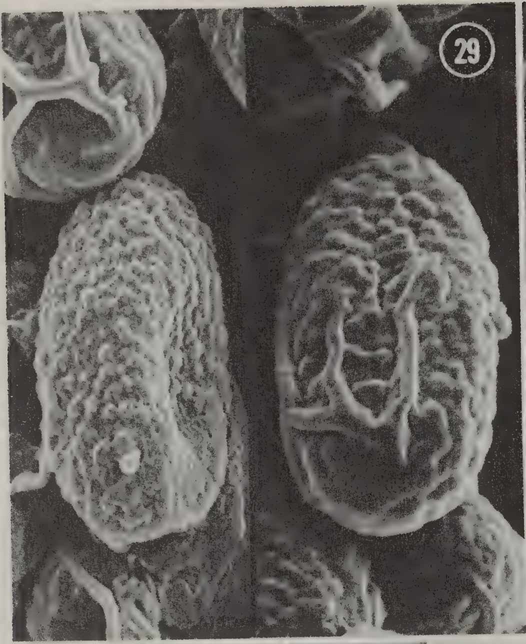

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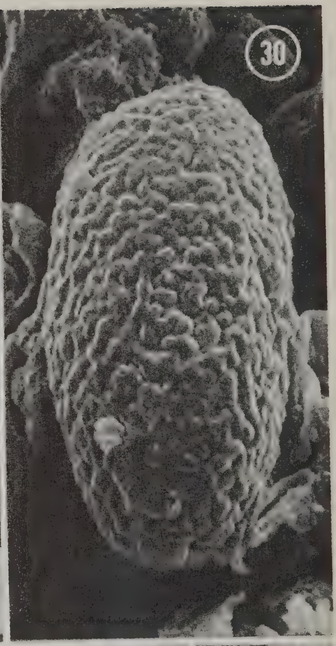

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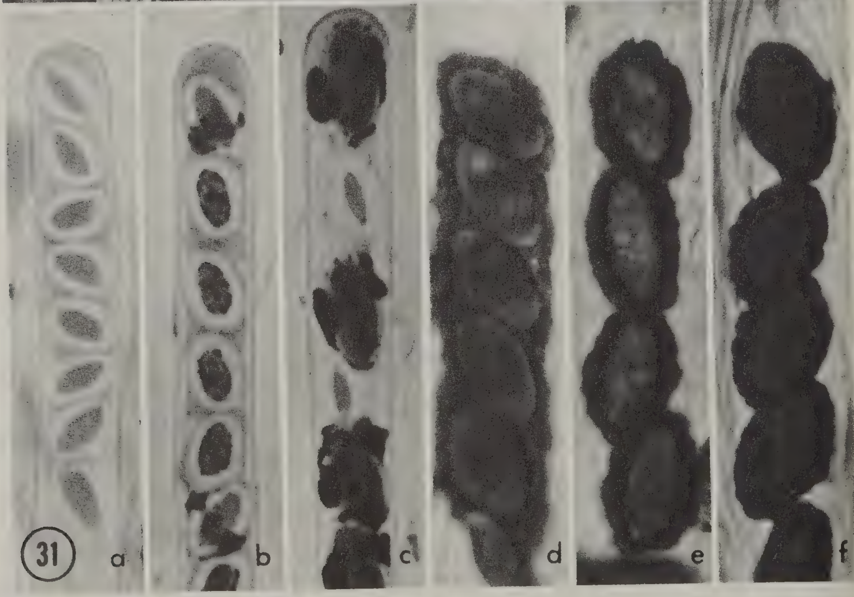

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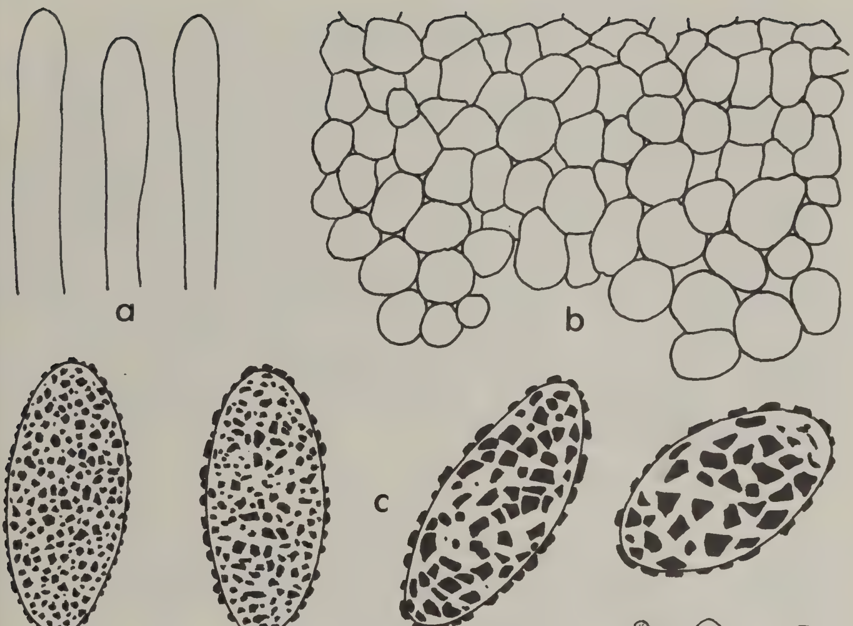

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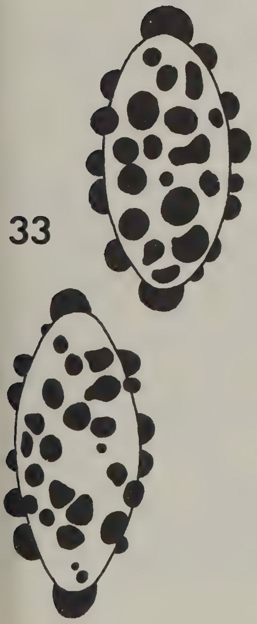

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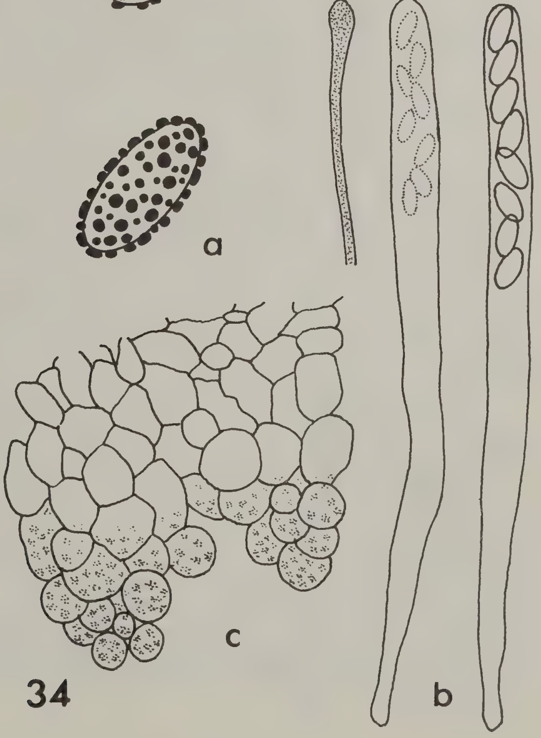

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A SUMMARY OF THE HYPOXYLON SERPENS COMPLEX

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ABSTRACT

The following taxa of the *Hypoxylon serpens* complex are discussed: *H. bipapillatum*, *H. carbonaceum* comb. nov., *H. serpens* var. *macrosporum*, *H. aeneum*, *H. aeneum* var. *aureoluteum* var. nov., *H. atropurpureum*, *H. atropurpureum* var. *brevistipitatum* var. nov., *H. caries* and *H. serpens*. Additionally, three isolates that are allied to *H. serpens* and which produce the teleomorph in culture are not accorded formal infraspecific recognition herein, but each is informally designated by the name of its collector: *H. serpens* "Barron" isolate; *H. serpens* "Carroll" isolate and *H. serpens* "Petrini" isolate. A key based on teleomorphic features is presented. Teleomorphic and anamorphic features are presented in tables and illustrations.

J. H. Miller, in his monumental monograph of *Hypoxylon* (1961), presented a broad concept of *H. serpens* (Pers.: Fr.) Kickx which is widely considered to be untenable. *Hypoxylon serpens* as delimited by Miller includes a number of more or less related taxa that are separable on such characteristics as: ascospore size, color and germ slit morphology; ascus stipe length; conidial size and morphology; and cultural features. Recently, Pouzar (1985a, b) has broken up the *H. serpens* complex largely by redefining and resurrecting taxa which were considered by Miller to be synonymous with *H. serpens*. Moreover, he has placed *H. serpens* s. str., along with several new and redefined taxa, in the newly circumscribed genus *Nemania* S. F. Gray.

We have also been investigating the H. serpens complex and are largely in agreement with Pouzar's treatment. He has kindly sent LEP duplicates of much of the European material that he investigated. Our present contribution is to be considered largely as complementary and supplementary to Pouzar's fine studies. We have been able to study some European and North American taxa that were unavailable to Pouzar. We have likewise been able to study cultures and anamorphs of most taxa. Anamorphs of all taxa are referable to Geniculosporium Chesters & Greenhalgh.

We have only one major disagreement with Pouzar: the use of Nemania. He includes (in addition to the H. serpens complex) such species as H. conostomum Mont., but omits H. confluens (Tode: Fr.) West., H. udum (Pers.: Fr.) Fr., and H. mammatum (Wahlenb.) J. H. Miller (Pouzar, 1985a, b). In our opinion, all of these species are highly related and should not be separated into different genera. He states that his circumscription of the genus is narrow, embracing only the serpens complex and a few satellite species, but admits that the genus could be much more broadly circumscribed to include Rosellinia DeNot., Kretzschmaria Fr., and Ustulina L. and C. Tul. (Pouzar, 1985a). In our opinion, a very broad circumscription of the genus would be as counterproductive as the narrow circumscription. It seems as difficult to circumscribe Nemania as to delimit Hypoxylon, Rosellinia and Kretzschmaria. In his opinion, Nemania species are very close to Xylaria Hill ex Schrank (Pouzar, 1985a), i.e., in not containing bright stromatal pigments, in ascus ring morphology, and in the white entostromatal tissue often surrounding perithecia. In fact, Xylaria is a complex genus with as much diversity as Hypoxylon sensu Miller. It is thus probable that Nemania in Pouzar's sense is related to, for example, X. hypoxylon (L.: Fr.) Grev. and X. polymorpha (Pers.: Fr.) Grev., but highly doubtful that it is closely related to X. cubensis (Mont.) Fr. or X. poitei (Lév.) Fr. For the present, we continue to consider the fungi to be discussed herein as taxa of Hypoxylon.

Among the fungi that we treat herein are four isolates that regularly produce perithecia in culture. One of these -- H. atropurpureum var. brevistipitatum -- occurs on wood under natural conditions. Teleomorphs of the others are known only from cultures. Each has been isolated only once -- two of them as endophytes and one from soil. Each of these isolates shows distinctive cultural characteristics, including fruiting patterns. They clearly differ from one another. They have been considered in the literature as variants of H. serpens and are so considered here. Because their status in nature is unclear and because only one representative of each is extant, we are informally designating each by the name of its collector, as follows: H. serpens "Carroll isolate" after Fanny Carroll; H. serpens "Barron isolate" after George Barron; H. serpens "Petrini isolate" after Orlando Petrini. We have resisted the impulse to describe these isolates as formal taxa until additional isolations are made and/or stromata are obtained from nature. Additional material might show them to be species or to be taxonomic varieties of H. serpens or one of the closely related species discussed herein. In the meantime, mycologists (especially, perhaps, those interested in endophytes and soil fungi) can identify them.

The capacity of some of these fungi to produce perithecial stromata in culture seems taxonomically important. Numerous experiments performed by Malmgren (1977) and Kenerley (1975) with the aim of inducing perithecial formation in culture by normally nonfruiting isolates of H. serpens failed entirely. Some of the experiments attempted to induce perithecial formation of nonfruiting cultures by putting them on media with fruiting cultures or on media that had supported fruiting cultures. The requirements for fruiting are still unknown.

We present our data in several complementing ways. First, there is a dichotomous key to the fungi treated herein. Second, descriptions are given for fungi heretofore inadequately described and references presented for those adequately described elsewhere. Third, data on cultures, anamorphs and teleomorphs are summarized in tables. Lastly, ascospore and conidial characters are illustrated.

MATERIAL AND METHODS

Cultural studies were carried out with isolates from American and Czechoslovakian specimens and with existing cultures from LEP. SME medium (20 g malt extract, 17.7 g agar, 1000 ml water)(Kenerley and Rogers, 1976) was routinely employed. The cultures were initiated from discs of agar bearing mycelium cut from the margin of actively growing cultures. The Petri dishes were incubated at ca. 23°C with alternating 12 h fluorescent light and darkness. Descriptions were made when cultures were 4 to 5 weeks old. Measurements of microscopic characters were taken from material mounted in water, except for those of conidiophore rachis length. Conidiophores were fixed on Scotch brand Double-stick tape and mounted in lactophenol.

Key to *Hypoxylon serpens* and allied taxa based on teleomorphic characters.

1. Stromata formed on wood in nature - - - - - - - - - - 2

1. Stromata unknown in nature (except *H. atropurpureum* var. *brevistipitatum*). Developing in cultures from soil isolations or endophytes- 10

    2. Ascospores dark brown, with conspicuous germ slit running full-length or nearly so - 3

    2. Ascospores light brown to brown, with germ slit much less than full-length and conspicuous or so inconspicuous as to seem lacking altogether - - - - - - - - - - - - - - - 4

3. Ascospores (9.5-)11-13(-15) μm long, with rounded ends. Stromata dark brown, lacking conspicuous perithecial contours- - - *H. bipapillatum*

3. Ascospores (11-)12-13.5(-14) μm long, often with beaked ends. Stromata black with prominent perithecial contours - - - - - - - - - *H. carbonaceum*

    4. Ascospores 13-22 μm long - - - - - - - - - - - - 5

    4. Ascospores 9-14 μm long- - - - - - - - - - - - 7

5. Asci long-stipitate, (50-)70-121(-157) μm long, the spore-bearing part (0.6-)0.8-1.6(-2.4) times the length of the stipe. Ascospores (13-)15-18.5(-22) μm long - - - - *H. serpens* var. *macrosporum*

5. Asci short-stipitate, no longer than 90 μm long, the spore-bearing part 1.4-3.5 times the length of the stipe - - - - - - - - - - - - - - - - 6

    6. Ascospores (14-)15-18(-20) X (4.5-)5-6 (-7) μm, with conspicuous germ slit. Ascus tip bluing in iodine- - - - - - *H. aeneum*

    6. Ascospores (13-)15-17.5(-19) X (5-)6-7 (-7.5) μm, with obscure germ slit. Ascus tip not bluing in iodine or becoming very light blue- - - - - - *H. aeneum* var. *aureoluteum*

7. Ascospores narrowly rounded at each end - - - - - - - 8

7. Ascospores broadly rounded at one or both ends, almost rectangular in outline - - - - - - - - - 9

    8. Asci long-stipitate, (58-)70-120(-160) μm long, the spore-bearing part (0.5-) 0.7-1(-1.2) the length of the stipe. Ascospores (9-)10-11.5(-12.5) μm long- *H. atropurpureum*

    8. Asci short-stipitate, (34-)47-73(-90) μm, the spore-bearing part (0.8-)1-1.6(-2.1) the length of the stipe. Ascospores (10-)11-12.5(-14) μm long- - - - - - - - - - - - - - - - - - - *H. atropurpureum* var. *brevistipitatum*

9. Ascospores (8.5-)10-12(-12.5) X 3.5-5.5 μm- *H. caries*

9. Ascospores (10-)11.5-14(-18) X 4-6.5 μm - *H. serpens*

10. Ascospores (13-)14-16(-18) X 6-7 μm, with conspicuous germ slit surrounded by darkened area. Stromata usually formed in various areas of Petri plates- H. serpens "Barron isolate"

10. Ascospores smaller and germ slit less conspicuous. Stromata usually formed only near the perimeter of Petri plates - - - 11

11. Stromata up to 1 mm diameter, each containing a single perithecium. Ascospores (10-)11-12.5 (-14) X 4.5-6 μm- H. atropurpureum var. brevistipitatum

11. Stromata usually larger, each usually containing several perithecia- - - - - - - - - - - - - -12

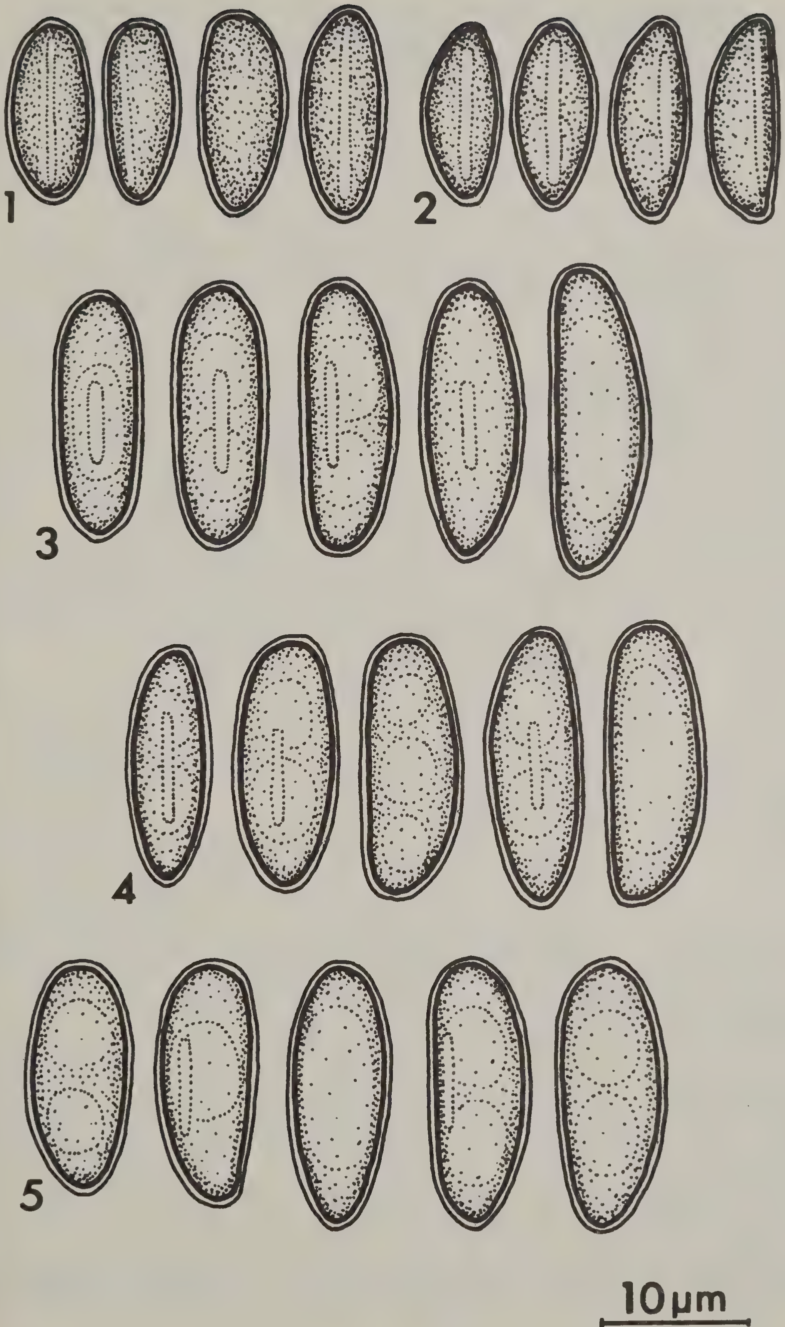
12. Stromata 5-15 X 3-8 mm, embedded in cottony, tan mycelium. Ascospores (11-)12.5-14.5(-16) X 4.5-6 μm - H. serpens "Carroll isolate"

12. Stromata 5-25 X 2-9 mm, embedded in floccose, white to cream mycelium. Ascospores (12-)12.5-13.5(-14) X 5-6 μm - H. serpens "Petrini isolate"

Hypoxylon bipapillatum Berk. & Curt., Jour. Phila. Acad. Nat. Sci. 2: 285. 1853.

Synonyms: Hypoxylon unitum (Fr.) Nits., Pyr. Germ., p. 44. 1867.

Figs. 1-5. Ascospores. Fig. 1. Hypoxylon bipapillatum. Fig. 2. H. carbonaceum. Fig. 3. H. serpens var. macrosporum. Fig. 4. H. aeneum. Fig. 5. H. aeneum var. aureoluteum.


10 µm

Hypoxylon subluteum Ell. & Everh., North American Pyrenomycetes, p. 648. 1892.
Hypoxylon lilacino-fuscum Bres., Flora Trid. 2: 43. t. 149. f.1. 1892.
Ustulina linearis Rehm, Hedwigia 31: 310. 1892.
Nemania bipapillata (Berk. & Curt.) Z. Pouzar, *Česká Mykologie* 39: 24. 1985.

Fig. 1, 14. Tables 1-7.

Description and illustration: Petrini & Petrini (1985), sub *Hypoxylon unitum*; Petrini & Müller (1986), sub *H. serpens* var. II.

Specimens examined:
Type: SOUTH AMERICA: Surinam, Herb. Schweinitz (PH). CZECHOSLOVAKIA: Čelákovice, "Lipovka" Wood, on *Quercus robur*, 19.XI.1978, Z. Pouzar, sub *Nemania bipapillata* (ex PRM, ZT); Beroun, between Dřínová hora and Velká hora, on *Corylus avellana*, 2.X.1981, Z. Pouzar, sub *Nemania bipapillata* (ex PRM, ZT). GERMANY: Westfalen, near Erdmanns, on *Quercus* sp., 1863, Nitschke, sub *Hypoxylon unitum* (B); Westfalen, Cappenberg, on *Corylus avellana*, VIII.1866, Nitschke, sub *Hypoxylon unitum* (B); Nr. 16, Nitschke, sub *Hypoxylon unitum* (B); Oestricher Hinterlandswald, Nitschke, sub *Hypoxylon unitum* (G); Berlin, Botanical Garden, on *Betula* sp., 1890, Sydow, sub *Ustulina linearis*, Isotype (ZT). ITALY: near Trento, "Gocciadoro", on *Ulmus suberosa*, IV.1888, Bresadola, sub *Hypoxylon lilacino-fuscum*, Lectotype (S). SWITZERLAND: Graubünden, Tamins, on *Corylus avellana*, 23.VII.1982, L. Petrini (ZT); Ticino, Comano, on *Castanea sativa*, 29.XII. 1982, L. & O. Petrini (ZT); Zürich, Hönggerberg, 2.XI. 1983, L. Petrini (ZT). UNITED KINGDOM: Devon, Exeter, Stoke Woods, on *Acer pseudoplatanus*, 23.IV.1982 (ZT); Durham City, Little High Wood, on *Quercus* sp., 18.V.1975, A. J. S. Whalley (J. D. Rogers herb.); Durham City, on *Quercus* sp., 3.III.1976, A. J. S. Whalley #388 (J. D. Rogers herb.); Durham City, Great High Wood, on *Fagus* sp., 3.III.1976, A. J. S. Whalley #389 (J. D. Rogers herb.); North Wales, Gwynedd, Bangor, on *Quercus* sp., 1.V.1982, L. Petrini (ZT)(cultured); North Wales, Gwynedd, on ? *Quercus* sp., 28.XII.1976, A. J. S. Whalley (J. D. Rogers herb.); North Wales, Gwynedd, on *Quercus* sp., 28.XII.1976, A. J. S. Whalley #468 (J. D. Rogers herb.); North Wales, Gwynedd, Bangor, Glyn Wood, on *Quercus* sp., 11.IV.1977, A. J. S. Whalley #488 (J. D. Rogers herb.); North Wales, Gwynedd, Bangor, Glyn Wood, on *Corylus avellana*, 24.III.1981, A. J.

S. Whalley #784 (ZT); North Wales, Gwynedd, Bangor, Glyn Wood, on *Quercus* sp., 30.XII.1982, A. J. S. Whalley #942, 943 (ZT). UNITED STATES: Louisiana, near St. Martinsville, 24.VIII.1890, A. B. Langlois #2276, sub *Hypoxylon subluteum*, Holotype (NY).

Distribution: Europe, North and South America.

This species was usually accepted as *Hypoxylon unitum* in older literature before Miller (1961) included it in his broad concept of *H. serpens*. However, the dark-colored ascospores with long germ slits and the cultural features support its recognition as a taxon separate from *H. serpens*. Based on its basionym, *Sphaeria unita* Fr.: Fr. (Fries, 1828), the name *H. unitum* would have priority over *H. bipapillatum*. However, there seems to be no extant Fries specimen to designate as a lectotype, making it difficult or impossible to apply this better-known name. Pouzar (1985b) considers *H. irregulare* Cooke to be a synonym of *H. bipapillatum*. However, the examined type material [Mauritius, Pouce, 1861, (K)] showed a completely black stroma and rather light brown ascospores. We thus consider *H. irregulare* to be a different taxon, and do not treat it further here.

Hypoxylon carbonaceum (Z. Pouzar) comb. nov.

Basionym: *Nemania carbonacea* Z. Pouzar, Česká Mykologie 39: 22. 1985.

Fig. 2. Tables 1-7.

Description: Pouzar (1985a)

Specimens examined:
CZECHOSLOVAKIA: near Kroměříž, "Zámeček" Wood, on *Acer campestris*, 13.IX.1972, Z. Pouzar, sub *Nemania carbonacea* (ex PRM, ZT); near Bratislava, Rusovce, on *Populus nigra*, 17.X.1979, Z. Pouzar, sub *Nemania carbonacea* (ex PRM, ZT).

Distribution: Central Europe

Hypoxylon carbonaceum differs from *H. bipapillatum* mostly in stromatal characters. The ascospores and asci are similar in size, but ascospores of *H. carbonaceum* show slightly beaked ends. No cultures of *H. carbonaceum* were obtained.

Hypoxylon serpens (Pers.: Fr.) Kickx var. *macrosporum* J. H. Miller, Mycologia 25: 327. 1933.

Synonym: *Nemania serpens* (Pers.: Fr.) S. F. Gray var. *macrospora* (J. H. Miller) Z. Pouzar, Česká Mykologie 39: 134. 1985

Figs. 3, 13. Tables 1-7.

Description and illustration: Miller (1961), Jong & Rogers (1972).

Specimens examined:
Holotype: UNITED STATES, Idaho, Copeland, Bethlehem mine, on dead wood, 21.VIII.1922, L. E. Wehmeyer (GAM).
COSTA RICA: San Pedro, Botanical Garden, University of Costa Rica, 8.VI.1962, G. C. Carroll #121 (G. C. Carroll herb.). CZECHOSLOVAKIA: near Hronská Dúbrava, Bučan, on *Carpinus betulus*, 23.X.1972, Z. Pouzar, sub *Nemania serpens* var. *macrospora* (ex PRM, ZT). UNITED STATES: California, St. Cruz Co., Nat. State Park Big Basin, on *Quercus* sp., 4.X.1985, L. & O. Petrini (ZT)(cultured); Idaho, Copeland, Bethlehem Gold Mines, on *Populus balsamifera*, 21.VIII.1922, C. H. Kauffman (GAM); Idaho, Deary, on *Acer* sp., 28.VI.1974, J. D. Rogers & C. M. Kenerley (J. D. Rogers herb.); Idaho, near Laird Park, on *Cornus stolonifera*, 29.IV.1968, H. Goree (J. D. Rogers herb.); Idaho, Latah Co., Moscow Mt., Carl Stevens Property, 2.VII.1977, J. D. Rogers (J. D. Rogers herb.); Idaho, Priest River, X.78, D. A. Glawe (J. D. Rogers herb.); New York, Ithaca, Beebe Lake, on *Quercus montana*, 22.VIII.1927, J. H. Miller, sub *Hypoxylon regale* Morg. (GAM); Washington, Whitman Co., Kamiak Butte Co. Park, 2.V.1982, J. D. Rogers (J. D. Rogers herb.)(cultured).

Distribution: Central Europe and North America. Appears to be common in western North America and rare elsewhere.

Hypoxylon serpens var. *macrosporum* differs from the typical variety in larger ascospores and ascus size. Our measurements of asci are: (133-)173-230(-260) µm total

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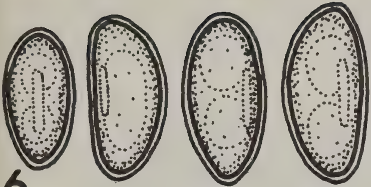
Figs. 6-12. Ascospores. Figs. 13 & 14. Conidia. Fig. 6. *Hypoxylon atropurpureum*. Fig. 7. *H. atropurpureum* var. *brevistipitatum*. Fig. 8. *H. caries*. Fig. 9. *H. serpens*. Fig. 10. *H. serpens* "Barron". Fig. 11. *H. serpens* "Carroll". Fig. 12. *H. serpens* "Petrini". Fig. 13. *H. serpens* var. *macrosporum*; *H. aeneum*; *H. aeneum* var. *aureoluteum*; *H. caries*; *H. serpens*; *H. serpens* "Barron"; *H. serpens* "Petrini". Fig. 14. *H. bipapillatum*; *H. atropurpureum*; *H. atropurpureum* var. *brevistipitatum*; *H. serpens* "Carroll".



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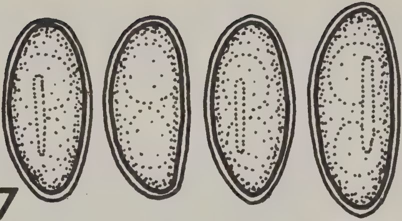

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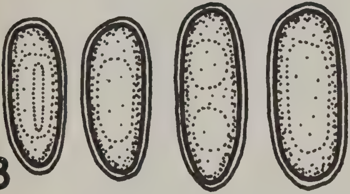

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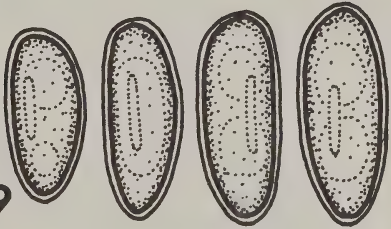

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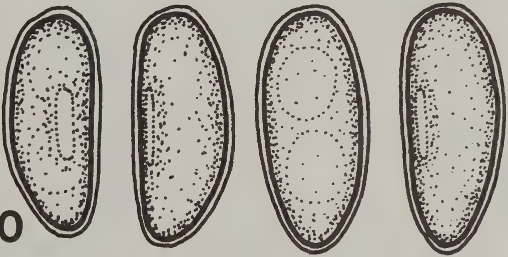

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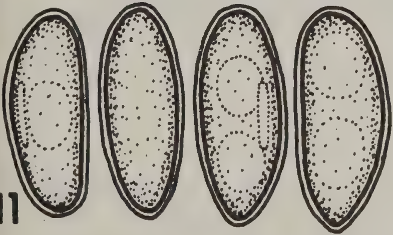

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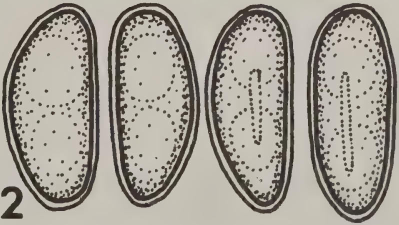

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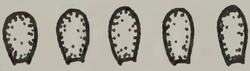

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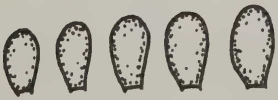


14

length, the stipes (50-)70-121(-157)µm; these average longer than those given by Miller (1961). Pouzar (1985b) reported a dark line in the center of some germ slits, but we did not observe it.

Cultures and conidiophores of var. *macrosporum* are somewhat darker than those of the *typical variety*. Conidial morphology and size of these two varieties seem identical. The only European specimen of var. *macrosporum* examined had slightly smaller ascospores *and a thicker* stroma than North American material, but no cultures were obtained from it.

Hypoxylon serpens var. *macrosporum* can be distinguished *from the rather similar varieties* of *H. aeneum* by the length of the ascus stipe and cultural *characters*.

Hypoxylon aeneum Nits., Pyr. Germ., p. 47. 1867.

Synonym: *Nemania aenea* (Nits.) Z. Pouzar, Česká Mykologie *39: 129.* 1985.

Figs. 4, 13, 15-18. Tables 1-7.

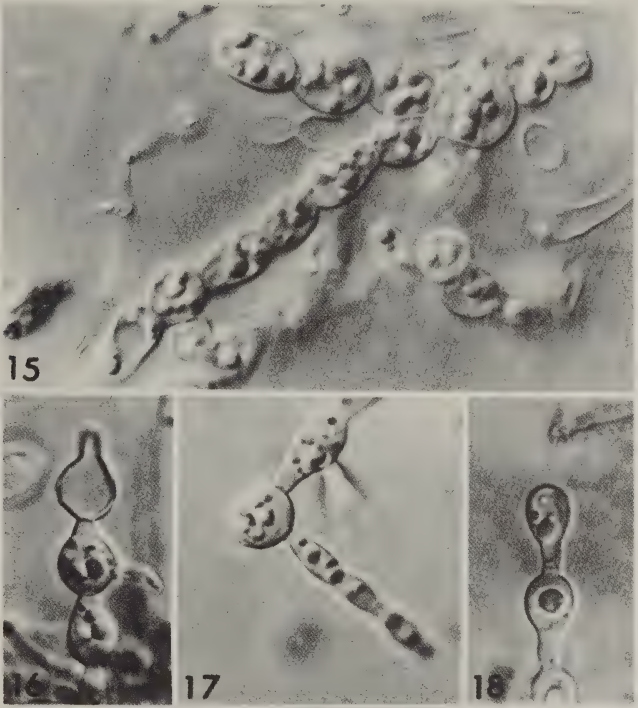
Description: Pouzar (1985b)

Specimens examined:
Lectotype: GERMANY, Westfalen, near Münster, Wolbeck, on *Fagus* sp., VIII.1865. Nitschke (B).
CZECHOSLOVAKIA: near Bratislava, Kalinkovo, wood near Kalinkovské rameno, on *Populus alba*, 12.X.1979, Z. Pouzar (ex PRM, ZT); near *Bratislava, Jur*, "Šúr" Wood, on *Ulmus* sp., 13.X.1979, Z. Pouzar (ex PRM, ZT); near *Bratislava*, Jur, "Šúr" Wood, on *Quercus robur*, 18.X.1979, Z. Pouzar (ex PRM, ZT); near *Čalovo, Číčov*, "Číčovský les" Wood, on *Salix alba*, 20.IX,1984, Z. Pouzar (ex PRM, ZT)(cultured).
GERMAN DEMOCRATIC REPUBLIC: Werder near Schwerin, on *Corylus avellana*, IX.1850, Wüstnei (B).

Distribution: Middle and Central Europe

The average length of the ascospores of *Hypoxylon aeneum* is slightly shorter than that of *H. serpens* var. *macrosporum*. Additionally, the ascus *stipes are much shorter and* the stromata more thin and brittle than those of *H. serpens* var. *macrosporum*.

Cultures of *H. aeneum have* a much faster growth rate than those of *H. serpens var.* *macrosporum*. After a month, they develop *branching chains of hyaline*, inflated cells, 9-15 µm in diameter, containing large oil drops. These cells might function as chlamydospores.



Figs. 15-18. Inflated chlamydospore-like cells from cultures of *H. aeneum*. All figs. X 1000.

Hypoxylon aeneum Nits. var. *aureoluteum* var. nov.

Figs. 5, 13. Tables 1-7.

A typo differt in latitudinibus ascosporarum, (5-)6-7(-7.5) µm, in obscura scissura germinationis.

Differs from the typical variety in width of ascospores (5-)6-7(-7.5) µm, and in the indistinct germ slit.

Description and illustration: Petrini & Petrini (1985), sub *H. serpens* var. *macrosporum*; Petrini & Müller (1986), sub *H. serpens* var. *macrosporum*.

Specimens examined:
Holotype: ITALY, Piemonte, Valsesia, above Scopa, on *Quercus* sp., 28.IX.1983, L. Petrini (ZT).
FRANCE: Charente, Angoulême, Bois de St. Martin, on *Quercus* sp., 8.X.1981, L. Petrini (ZT). SWITZERLAND: Graubünden, Station Untervaz, Heurütenen, 22.VIII.1981, L. Petrini & E. Müller (ZT)(cultured); Jura, St. Ursanne, Col de la Croix, on *Quercus* sp., 19.VI.1983, L. & O. Petrini (ZT); Ticino, Meride, 26.VIII.1982, L. Petrini & A. J. S. Whalley (ZT)(cultured); Zürich, Hönggerberg, on *Quercus* sp., 31.X.1984, L. Petrini (ZT)(cultured).

Distribution: Central Europe

The teleomorph of *H. aeneum* var. *aureoluteum* is very similar to that of the typical variety. It differs from the typical variety in having: wider ascospores with very obscure germ slits; ascus rings that blue only slightly in iodine or do not blue at all; cultures with orange coloration that lack hyaline, inflated chlamydospore-like cells and grow rather slowly. Moreover, var. *aureoluteum* seems to fruit mainly on *Quercus*.

Hypoxylon atropurpureum (Fr.: Fr.) Fr., Summa Veg. Scand., p. 384, 1849.

Basionym: *Sphaeria atropurpurea* Fr., Syst. Myc. 2: 340. 1823. non Tode.
Synonyms: *Hypoxylon reticulatum* Karst., Notiser ur Saellskapets pro Fauna et Flora Fennica foerhandlingar 13: 238. 1873.
Nemania atropurpurea (Fr.: Fr.) Z. Pouzar, Česká Mykologie 39: 19. 1985.

Figs. 6, 14. Tables 1-7.

Description: Pouzar (1985a)

Specimens examined:
Type: SWEDEN, Fries, Scler. Suec. Exs. #75, sub *Sphaeria atropurpurea* (K, UPS).
CANADA: Ontario, L. Timagami, Lake Portage, on *Populus* sp., 7.IX.1933, R. F. Cain, sub *Hypoxylon serpens* (GAM). CZECHOSLOVAKIA: near Jaroměřice nad Rokytnou, "V Jedli" Wood, on *Tilia platyphyllos*, 15.IX.1981, Z. Pouzar, sub *Nemania atropurpurea* (ex PRM, ZT); near Velké Mitrovice, "Chynínské buky", on *Fagus silvatica*, 22.IX.1983, Z.

Pouzar, sub *Nemania atropurpurea* (ex PRM, ZT); near Stříbrná Skalice, Studený vrch, on *Fagus silvatica*, 11.XI.1984, Z. Pouzar, sub *Nemania atropurpurea* (ex PRM, ZT)(cultured). FINLAND: Mustiala, on *Polyporus pinicola*, IX.1868, P. A. Karsten, Fung. Fenn. Exs. #773, sub *Hypoxylon reticulatum*, Type (H, K).

Distribution: Northern and Central Europe, Canada

The teleomorph of *Hypoxylon atropurpureum* differs from the typical variety of *H. serpens* mainly in the shape of the ascospores and in the more conspicuous germ slit. It also differs from typical *H. serpens* in cultural characters and size of conidia.
Conidia of *H. atropurpureum* germinate readily.

Hypoxylon atropurpureum (Fr.: Fr.) Fr. var.
brevistipitatum var. nov.

Figs. 7, 14. Tables 1-7.

A typo differt solum in stipitibus ascorum, (34-)47-73(-90) µm.

Differs from typical variety solely in length of ascus stipes, (34-)47-73(-90) µm.

Description and illustration: Petrini & Petrini (1985), sub *H. irregulare*; Petrini & Müller (1986), sub *H. serpens* var. I.

Specimens examined:
Holotype: SWITZERLAND, Neuchâtel, Creux-du-Van, on *Fagus silvatica*, 1.VI.1985, L. Petrini (ZT)(cultured).
FRANCE: Savoy, Thonon, Bois de Goudrée, 4.VII.1981, L. Petrini (ZT). SWITZERLAND: Aargau, Erlinsbach, Egg, on *Quercus* sp., 20.V.1982, B. Erb (ZT)(cultured); Graubünden, Dischmatal, Teufi, on *Betula* sp., 20.V.1981, L. Petrini (ZT)(cultured); Graubünden, Dischmatal, Teufi, on *Alnus viridis*, 2.IX.1982, L. Petrini (ZT); Graubünden, Station Untervaz, Heurütenen, 24.IX.1983, L. & O. Petrini (ZT).

Distribution: Central Europe

Hypoxylon atropurpureum var. *brevistipitatum* has much shorter ascus stipes, slightly larger ascospores and smaller stromata than the typical variety. Cultural differences likewise allow separation from *H. atropurpureum*. In general, however, it is very similar to the typical variety. One isolate fruited in culture. Uniperitheciate stromata are formed at the periphery of the Petri plate.

Hypoxylon caries (Schw.) Sacc., Syll. Fung. 1: 393. 1882.

Basionym: *Sphaeria caries* Schw., Trans. Am. Phil. Soc. Phila. 4: 194. 1834.

Figs. 8, 13. Tables 1-7

Description and illustration: Miller (1961); Rogers (1985).

Specimens examined:
Type: UNITED STATES, Pennsylvania, Bethlehem, #1222, sub *Sphaeria caries* (PH).
UNITED STATES: Georgia, Athens, Lake Dixie, on *Liriodendron tulipifera*, 26.III.1931, J. H. Miller, sub *Hypoxylon serpens* (GAM); Illinois, Pope Co., Dixon Springs, 23.X.1984, J. D. Rogers (J. D. Rogers herb.) (cultured); Pennsylvania, Lehigh, #1222-76, sub *Sphaeria caries* (PH); Texas, Rockne, 12.VI.1965, G. C. Carroll #960 (G. C. Carroll herb.).

Distribution: North America

Martin (1967) and Pouzar (1985b) consider *Hypoxylon caries* to be conspecific with *H. serpens*. However, the smaller average ascospore size, oblong to cylindrical ascospore shape, and some differences in cultural appearance cause us to recognize *H. caries* as a species. Miller (1961) put *H. balansae* Speg. into synonymy with *H. caries*, but the material of an isotype of *H. balansae* from the herbarium in Geneva [Fungi Guar. #77 (3978)] is not *H. caries* and, indeed, shows some similarities to *Biscogniauxia* spp.

Hypoxylon serpens (Pers.: Fr.) Kickx, Fl. Crypt. Louv., p. 115. 1835.

Basionym: *Sphaeria serpens* Pers.: Fr., Syn. Meth. Fung., p. 20. 1801.
Synonyms: *Nemania serpens* (Pers.: Fr.) S. F. Gray, Nat. arr. Brit. plants, p. 516. 1821.
Gamosphaera serpens (Pers.: Fr.) Dumortier, Observ. Bot., p. 90. 1822.
Sphaeria colliculosa Schw., Schr. Nat. Ges. Leipzig 1: 36. 1822.
Sphaeria hydnicola Schw., Philad. Journ. Acad. Nat. Sci. 5: 14. 1825.
Hypoxylon colliculosum (Schw.) Curt., Geol. & Nat. Hist. Survey, N. C. 3: 140. 1867.
Hypoxylon epirhodium Berk. & Rav., Grevillea 4: 51. 1875.

Hypoxylon hydnicola (Schw.) Sacc., Syll. Fung. 1: 383. 1882.

Figs. 9, 13. Tables 1-7.

Description and illustration: Chesters & Greenhalgh (1964), Jong & Rogers (1972), Petrini & Müller (1986).

Specimens examined:
Type: Herb. Persoon #910. 269-703, sub *Sphaeria serpens* (L).
CANADA: British Columbia, Vancouver Island, Goldstream Park, 30.XII.1985, L. Petrini (ZT). CHILE: Corral, XII. 1905, R. Thaxter #6850, sub *Hypoxylon glomeratum* Cooke (J. D. Rogers herb.). CZECHOSLOVAKIA: near Valtice, Randezvous in Boří, on *Quercus cerris*, 6.X.1977, Z. Pouzar, sub *Nemania serpens* (ex PRM, ZT); near Beroun, between Velká hora and Dřinová hora, on *Acer campestris*, 13.X.1978, Z. Pouzar, sub *Nemania serpens* (ex PRM, ZT); near Mělník, "Úpor" Wood, on *Betula verrucosa*, 16.XI.1978, Z. Pouzar, sub *Nemania serpens* (ex PRM, ZT). DENMARK: near Copenhagen, Dyrehaven, on *Fagus* sp., 20.X.1962, A. Munk #122 (G. C. Carroll herb.); near Kongedal, Sjaelland, on *Fagus* sp., 30.VIII.1963, G. C. Carroll #455 (G. C. Carroll herb.). FRANCE: Charente, Angoulême, Bois de St. Martin, on *Quercus* sp., 8.X.1981, L. Petrini (ZT); Pyrénées Occidentales, Lac de Bious-Artigues, 13.X.1981, L. Petrini & F. Candoussau (ZT). GERMANY: Westfalen, near Münster, Erdmanns, VIII.1865, Nitschke, sub *Hypoxylon aeneum* (B). SWEDEN: Fries, Scler. Suec. Exs. 47, sub *Sphaeria serpens* (K). SWITZERLAND: Bern, Brünigpass, on *Fagus silvatica*, 18.X.1982, L. Petrini (ZT)(cultured); Graubünden, Station Untervaz, Heurütenen, 31.VIII.1982, L. Petrini & A. J. S. Whalley (ZT); Graubünden, Station Untervaz, Oberau, 22.IX. 1983, L. & O. Petrini & F. Candoussau (ZT); Jura, St. Ursanne, Col de la Croix, on *Quercus* sp., 19.VI.1983, L. & O. Petrini (ZT); Thurgau, Scharenwald, 14.II.1982, L. & O. Petrini (ZT); Ticino, Meride Fontana, 26.VIII.1982, L. Petrini & A. J. S. Whalley (ZT); Ticino, Morbio superiore, Val della Creda, on *Quercus* sp., 4.IV.1983, L. & O. Petrini (ZT)(cultured); Ticino, Monte di Caslano, on *Castanea sativa*, 5.IV.1983, L. & O. Petrini (ZT)(cultured); Zürich, Lägern, on *Fagus silvatica*, 20.X.1981, E. Müller (ZT); Zürich, Station Zweidlen, on *Quercus* sp., 14.VI.1983, L. Petrini & E. Muller (ZT). UNITED KINGDOM: near Cambridge, Belvedere Wood, on *Quercus* sp., IX.1974, A. J. S. Whalley (J. D. Rogers herb.); Devon, Exeter, Stoke Woods, on *Corylus avellana*, 23.IV.1982, L. Petrini (ZT)(cultured); Durham

City, Castle Eden, on *Fraxinus* sp., 19.V.1975, A. J. S. Whalley (J. D. Rogers herb.); Durham City, Great High Wood, on ? *Quercus* sp., 3.III.1976, A. J. S. Whalley #387 (J. D. Rogers herb.); Durham Co., Hawthorne, on *Fraxinus* sp., 12.XI.1976, A. J. S. Whalley #463 (J. D. Rogers herb.); Hertfordshire, Great Wood, Potters Bar, 20.III.1976, A. J. S. Whalley (J. D. Rogers herb.); North Wales, Gwynedd, on ? *Rhododendron* sp., 15.V.1976, A. J. S. Whalley (J. D. Rogers herb.); North Wales, Llanfair p.g., on *Fraxinus* sp., 9.IV.1977, A. J. S. Whalley #481(J. D. Rogers herb.); North Wales, Llangollen, on *Fraxinus* sp., 24.VII.1978, A. J. S. Whalley (J. D. Rogers herb.). UNITED STATES: Arizona, near Tucson, Mt. Lemmon, Bear Wallow, on ? *Pseudotsuga* sp., VIII.1980, J. D. Rogers (J. D. Rogers herb.) (cultured); Idaho, Copeland, Bethlehem Mines, 25.VIII.1922, C. H. Kauffman & L. E. Wehmeyer #4242 (GAM); Idaho, Priest River, 15.X.1978, D. Glawe (J. D. Rogers herb.)(cultured); Maine, Kittery Point, on *Quercus* sp., IX.1898, R. Thaxter (J. D. Rogers herb.); North Carolina, Salem, Schweinitz #1207-61, sub *Sphaeria hydnicola*, Type (PH); North Carolina, Salem, Schweinitz #1197-51, sub *Sphaeria colliculosa*, Type (PH); Oregon, Lane Co., McKenzie Trail, 10.X.1985, L. Petrini (ZT)(cultured); Pennsylvania, Allegheny State Park, 9.VI.1961, G. C. Carroll #123 (G. C. Carroll herb.); South Carolina, herb. Berkeley, sub *Hypoxylon epirhodium*, Type (K); Washington, Stehekin, on Lake Trail, on *Acer macrophyllum*, 10.VIII.1976, J. D. Rogers (J. D. Rogers herb.)(cultured).

Distribution: Cosmopolitan

The typical variety of *H. serpens* has light brown ascospores with broadly rounded ends and short, obscure germ slit. The apical ascus ring is only rarely blued with iodine. European and North American teleomorphic specimens seem identical. Cultures from European material show more variation in colony color and lack the dark brown to blackish colony margins which characterize cultures from North American material. A dark longitudinal area in the ascospore germ slit was reported by Pouzar (1985b), but we did not observe it.

Hypoxylon serpens (Pers.: Fr.) Kickx "Barron isolate"

Figs. 10, 13. Tables 1-7.

Colonies on SME covering 9 cm diam Petri plate in 20 days, with mycelium cottony to floccose, tan to brown to grey, with strong earthy odor. Reverse cream to greyish.

Conidiophores and perithecial stromata formed throughout the colonies, the latter in 20 days.

Conidiophores upright or prostrate, unbranched or asymmetrically or verticillately branched, subhyaline to light brown, smooth, sometimes exceeding 200 µm X 2-3 µm. *Conidiogenous regions* terminal or intercalary, geniculate, with conspicuous crater-shaped conidial secession scars. Conidia produced holoblastically. *Conidia* hyaline to subhyaline, smooth, obovoid, with flattened bases indicating former points of attachment to conidiogenous cell, 3-5(-8) X 2-3 µm.

Stromata elongate, flattened, 5-35 X 2-5 X 0.5-1 mm, black but often covered with brown felty mycelium, with finely papillate perithecial ostioles. *Perithecia* ca. 0.7 mm diam. Asci 8-spored, cylindrical, long-stipitate, (118-)136-189(-223) µm total length X 8-13 µm wide, the spore-bearing parts (81-)90-112(-121) µm, and stipes (28-) 40-82(-112) µm, with the apical ring bluing in Melzer's iodine reagent, inverted hat-shaped, 3-5 X 2.5-3 µm. *Ascospores* light brown to brown, one-celled, broadly ellipsoid-inequilateral, smooth, (13-)14-16(-18) X 6-7 µm, with short conspicuous germ slit which is surrounded by a darkened area.

Culture examined: isolated from soil, Canada, G. Barron.

Hypoxylon serpens "Barron isolate" has been isolated only once from soil, as far as we know. Its fructifications have never been found on wood. It is distinct from the typical *H. serpens* in its ability to produce the teleomorph in culture, in the conspicuous germ slit and in cultural characteristics. This taxon has been called *H. serpens* in the literature (Rogers, 1975; Jensen, 1981).

Hypoxylon serpens (Pers.: Fr.) Kickx "Carroll isolate".

Figs. 11, 14. Tables 1-7.

Colonies on SME covering 9 cm diam Petri plate in 10 days, with mycelium appressed to cottony, tan. Reverse cream to light brown. Conidiophores formed over entire culture. Perithecial stromata formed only at periphery of plate in 30-40 days.

Conidiophores upright or prostrate, unbranched or asymmetrically or verticillately branched at several ranks, subhyaline to light brown, smooth, sometimes exceeding 200 µm X 2-4 µm wide. *Conidiogenous regions* terminal or intercalary, geniculate, with conspicuous crater-shaped conidial secession scars. Conidia produced holoblastically. *Conidia* hyaline to subhyaline, smooth, obovoid, with flattened bases indicating former points of attachment to conidiogenous cell, 4-5(-8) X 2-3 µm.

Stromata elongate to discoid, flattened to pulvinate, 5-15 X 3-8 X 1 mm, black but often covered with grey mycelium or brown conidiophores and surrounded by white mycelial weft, with obscure to finely papillate perithecial ostioles. *Perithecia* ca. 0.6 mm diam. *Asci* 8-spored, cylindrical, long-stipitate, 138-163 µm total length X 8-15 µm wide, the spore-bearing parts 78-95 µm and stipes 50-75 µm, with the apical ring bluing in Melzer's iodine reagent, inverted hat-shaped, 3 X 2.5-3 µm. *Ascospores* light brown, one-celled, ellipsoid-inequilateral, smooth, (11-)12.5-14.5(-16) X 4.5-6 µm, with short obscure to fairly conspicuous germ slit.

Culture examined: endophyte isolated from *Pinus nigra*, France, Seine et Marne, Fontainbleau Forest, 5.I.1974, F. Carroll.

The only record of *Hypoxylon serpens* "Carroll isolate" is a culture obtained as an isolated endophyte from *Pinus nigra*. This isolate, also mentioned as *H. serpens* in the literature (Jensen, 1981), differs from *H. serpens* "Barron isolate" in its smaller ascospores (average), in cultural appearance and in usually producing stromata only at the periphery of the colony (this feature has become less regular as stock cultures have aged). It can be distinguished from typical *H. serpens* mainly on ascospore shape, differences in cultures, slightly larger conidia, and the ability to produce fertile stromata in culture. Malmgren (1977) did an intensive cultural study of typical *H. serpens*, *H. serpens* "Barron isolate", and *H. serpens* "Carroll isolate". Various experiments were carried out in attempts to induce the typical variety to fruit and to change the fruiting pattern of "Carroll isolate" (i.e., to induce fruiting in parts of colonies other than the periphery). Her experiments failed to induce fruiting in the typical variety and, moreover, to alter fruiting patterns in the other isolates. It was strongly indicated that cultural phenomena reported herein are very stable.

Hypoxylon serpens (Pers.: Fr.) Kickx "Petrini isolate"

Figs. 12, 13. Tables 1-7.

Colonies on SME covering 9 cm diam Petri plate in 15 days, with mycelium appressed to floccose, cream to light tan toward margins. Reverse light brown. Conidiophores fairly abundant to scarce, mainly forming from ascospore germ tubes and associated with stromata. Stromata forming in 15 days near periphery of plate.

Conidiophores upright or prostrate, unbranched or asymmetrically branched, subhyaline to light brown, smooth, often exceeding 200 µm in length X 2-3 µm wide. *Conidiogenous regions* terminal to intercalary, geniculate, with conspicuous crater-like conidial secession scars. Conidia produced holoblastically. *Conidia* hyaline to subhyaline, smooth, obovoid to subgloboid, with flattened bases indicating former points of attachment to conidiogenous cell, 3-4 X 2.5-3 µm.

Stromata elongate to discoid, flattened to somewhat pulvinate, 5-25 X 2-9 X 1 mm, black, but often covered with tan mycelium, with perithecial ostioles obscure to finely papillate. *Perithecia* up to 0.8 mm diam. *Asci* 8-spored, cylindrical, long-stipitate, (120-)133-191(-227) µm total length X 7-10 µm wide, the spore-bearing parts (75-)82-99(-107) µm and stipes (36-)47-95(-125) µm, with the apical ring bluing in Melzer's iodine reagent, inverted hat-shaped, 3-3.5 X 2-2.5 µm. *Ascospores* light brown, one-celled, ellipsoid-inequilateral, smooth, (12-)12.5-13.5(-14) X 5-6 µm, with short obscure to fairly conspicuous germ slit.

Culture examined: isolated endophyte from *Mahonia nervosa*, United States, Oregon, V.1980, O. Petrini.

Hypoxylon serpens "Petrini isolate" is known only from a culture originating from an isolated endophyte of *Mahonia nervosa*. Its teleomorph and cultural characters differ from those of any other taxon or fruiting isolate of *H. serpens*.

Table 1. CULTURAL FEATURES

	Growth rate Days to reach margin of 9 cm Petri dish	Color
H. bipapillatum	35	*1 - Dark grey to black *2 - White
H. carbonaceum	NO CULTURES OBTAINED	
H. serpens var. *macrosporum*	30	1-2 - Dark grey-brown *3 - Dark brown to black
H. aeneum	15	Tan with light brown to grey areas
H. aeneum var. *aureoluteum*	Attaining 40-50 mm in diameter after 35 days	1- White to light orange with dark grey areas 2 - Orange to orange-grey
H. atropurpureum	15	1 - Light grey 2 - Tan

Table 1 (cont.)

H. atropurpureum var. *brevistipitatum*	30	Cream to light brown
H. caries	20	Light brown-grey
H. serpens	30	Light grey, grey-brown or tan
H. serpens "Barron"	20	Tan to brown
H. serpens "Carroll"	10	Tan
H. serpens "Petrini"	15	1 - Cream 2 - Light tan

*1 - At the center of culture
*2 - Toward margin
*3 - At the margin

Table 2. CULTURAL FEATURES (continued)

	Appearance of mycelium and colony surface	Special features
H. bipapillatum	*1 - Velvety to felty *2 - Felty to appressed	1 - Forming dark brown to black stromatic structures composed of dark brown hyphae with short protuberances
H. carbonaceum	NO CULTURES OBTAINED	
H. serpens var. *macrosporum*	Dry, powdery	Surface sometimes zonate; margin undulate
H. aeneum	Fluffy, with pustules of dense velvety mycelium	Developing inflated hyaline cells in white clusters after 30 days
H. aeneum var. *aureoluteum*	1 - Felty to appressed 2 - Growing through the agar to bottom of plate	Surface widely zonate; margin undulate
H. atropurpureum	1 - Cottony to floccose 2 - Fluffy to appressed	- - - - - - - - - - - - - -

Table 2 (cont.)

H. atropurpureum var. *brevistipitatum*	Felty to appressed, aggregating in white clusters and sometimes in radiate strands	3* - Sometimes perithecial primordia present after 30 days
H. caries	1 - Cottony to velvety 2 - Floccose to powdery	- - - - - - - - - - - -
H. serpens	Powdery to slightly floccose	Surface sometimes zonate; margin undulate. American isolates dark grey to black. European isolates lighter.
H. serpens "Barron"	Cottony to floccose	1 - Developing fertile stromata after 20 days
H. serpens "Carroll"	Cottony to appressed	3 - Developing fertile stromata after 30-40 days
H. serpens "Petrini"	Floccose to appressed	3 - Developing fertile stromata after 15 days

*1 - At the center of culture
*2 - Toward margin
*3 - At the margin

Table 3. ANAMORPH FEATURES

	Size of conidia (μm)	Location of conidiophores in colony	Length of intercalary rachis (μm)	Pigmentation of conidiophores
H. bipapillatum	4.5-6 X 2.5-4	Near the center, restricted to light brown areas. Occurring after 30 days	5-25	Subhyaline to light brown
H. carbonaceum	NO CULTURES OBTAINED			
H. serpens var. *macrosporum*	3-4 X 2.5-3	Densely scattered over the whole colony	14-90	Dark grey-brown
H. aeneum	3.5-4 X 2-3	General over the entire colony but soon disintegrating	2-40	Subhyaline to light brown
H. aeneum var. *aureoluteum*	3-4 X 2-3	In concentric circles, following the zonate pattern. Occurring after 30-35 days	5-20	Subhyaline
H. atropurpureum	4.5-6 X 2.5-3.5	Over the entire colony. Forming dense pustules around the center	7-45	Subhyaline to light brown

Table 3 (cont.)

H. atropurpureum var. *brevistipitatum*	(3.5-)4-5 X 2-3	First around the center in dark grey patches. Later in larger tan areas. Colored areas spread over the entire colony	1-25	Subhyaline to light brown
H. caries	3-3.5 X 2-2.5	Over the entire colony	7-50	Subhyaline to light brown
H. serpens	3-4 X 2-2.5(-3)	Densely scattered over the entire colony	7-65	Subhyaline to light brown
H. serpens "Barron"	3-5(-8) X 2-3	Scarce. Over the entire colony but soon disintegrating	up to 50	Subhyaline to light brown
H. serpens "Carroll"	4-5(-8) X 2-3	Over the entire colony but soon disintegrating	8-23	Subhyaline to light brown
H. serpens "Petrini"	3-4 X 2.5-3	Scarce. Around the stromata and produced from germinating ascospores	up to 65	Subhyaline to light brown

Table 4. ASCUS AND ASCOSPORE FEATURES

	Ascospore dimensions (μm)	Ascospore color	Germ slit
H. bipapillatum	(9.5-)11-13(-15) X 4.5-7	Dark brown	Full length of spore; conspicuous
H. carbonaceum	(11-)12-13.5(-14) X 4.5-6	Dark brown	Full length of spore; conspicuous
H. serpens var. *macrosporum*	(13-)15-18.5(-22) X 5-7.5	Light brown	Short; obscure to conspicuous
H. aeneum	(14-)15-18(-20) X (4.5-)5-6(-7)	Light brown	Short; conspicuous
H. aeneum var. *aureoluteum*	(13-)15-17.5(-19) X (5-)6-7(-7.5)	Light brown	Short; obscure
H. atropurpureum	(9-)10-11.5(-12.5) X 4.5-6	Brown to light brown	Short; conspicuous
H. atropurpureum var. *brevistipitatum*	(10-)11-12.5(-14) X 4.5-6	Brown to light brown	Short; conspicuous

Table 4 (cont.)

H. caries	(8.5-)10-12(-12.5) X 3.5-5.5	Light brown	Short; obscure
H. serpens	(10-)11.5-14(-18) X 4-6.5	Light brown	Short; obscure
H. serpens "Barron"	(13-)14-16(-18) X 6-7	Light brown	Short; very conspicuous
H. serpens "Carroll"	(11-)12.5-14.5(-16) X 4.5-6	Light brown	Short; obscure to conspicuous
H. serpens "Petrini"	(12-)12.5-13.5(-14) X 5-6	Light brown	Short; obscure to conspicuous

Table 5. ASCUS AND ASCOSPORE FEATURES (continued)

	Shape of ascospore apices	Ascus stipe (µm)	Ratio of spore-bearing part to stipe	Ascus tip reaction in iodine
H. bipapillatum	Narrowly rounded	(46-)70-121(-165)	0.5-1.2(-1.9)	+
H. carbonaceum	Narrowly rounded. Sometimes with beaked ends	(40-)44-74(-85)	0.9-1.8(-2.3)	+
H. serpens var. *macrosporum*	Narrowly or broadly rounded	(50-)70-121(-157)	(0.6-)0.8-1.6(-2.4)	+
H. aeneum	Narrowly or broadly rounded	(13-)31-62(-90)	(0.9-)1.4-3.5(-7.3)	+
H. aeneum var. *aureoluteum*	Narrowly or broadly rounded	(30-)38-63(-81)	(1-)1.5-2.5(-3.2)	- or faintly +
H. atropurpureum	Narrowly rounded	(58-)70-120(-160)	(0.5-)0.7-1(-1.2)	+

Table 5 (cont.)

H. atropurpureum var. *brevistipitatum*	Narrowly rounded	(34-)47-73(-90)	(0.8-)1-1.6(-2.1)	+
H. caries	Broadly rounded; almost cylindrical	55-120	0.4-1.3	+
H. serpens	Broadly rounded	(32-)60-103(-138)	0.6-1.5(-1.8)	Mostly - Sometimes +
H. serpens "Barron"	Narrowly or broadly rounded	(28-)40-82(-112)	(0.7-)1.2-2.4(-3.4)	+
H. serpens "Carroll"	Narrowly or broadly rounded	50-75	1.2-1.8	+
H. serpens "Petrini"	Narrowly or broadly rounded	(36-)47-95(-125)	(0.8-)1-1.8(-2.8)	+

Table 6. STROMATAL FEATURES

	Size of stroma (mm)	Color of stroma	Ostioles
H. bipapillatum	3-40 X 1-20 X 1-1.2	Dark brown to black	Finely papillate
H. carbonaceum	6-85 X 3-25 X 0.6-0.7	Black	Finely to coarsely papillate
H. serpens var. *macrosporum*	2-60 X 2-15 X 1-1.5	Dark brown to black	Barely protruding or finely papillate
H. aeneum	2-30 X 1-10 X 0.5	Brown to black	Finely papillate
H. aeneum var. *aureoluteum*	5-35 X 1-5 X 0.8	Brown to black	Barely protruding or finely papillate
H. atropurpureum	10-80 X 5-25 X 1	Black, sometimes covered with purplish mass of spores	Finely to coarsely papillate
H. atropurpureum var. *brevistipitatum*	5-25 X 1-10 X 0.8	Dark brown to black	Barely protruding or finely papillate

Table 6 (cont.)

H. caries	3-45 X 2-15 X 1	Grey-brown, brown to black	Finely papillate to slightly umbilicate
H. serpens	5-70 X 2-30 X 0.8-1	Dark brown to black, sometimes covered with greenish mass of spores	Finely, seldom coarsely papillate. Occasionally in annulate depressions
H. serpens "Barron"	5-35 X 2-5 X 0.5-1	Black, covered with brown, felty mycelium	Finely papillate
H. serpens "Carroll"	5-15 X 3-8 X 1	Black, covered with grey mycelium or brown conidiophores. When older surrounded by white mycelial weft	Barely protruding
H. serpens "Petrini"	5-25 X 2-9 X 1	Black, covered with white to cream mycelium	Barely protruding or finely papillate

Table 7. STROMATAL FEATURES (continued)

	Contours of perithecia on the stroma surface	Size of perithecia (mm)
H. bipapillatum	Not present	Up to 0.9
H. carbonaceum	Prominent	Up to 1
H. serpens var. *macrosporum*	Not present or only at the margin	Up to 1
H. aeneum	Present	Up to 0.5
H. aeneum var. *aureoluteum*	Not present	Up to 0.8
H. atropurpureum	Prominent	Up to 1
H. atropurpureum var. *brevistipitatum*	Not present	Up to 0.7
H. caries	Not present or only at the margin	Up to 0.7
H. serpens	Not present or only at the margin	Up to 0.9
H. serpens "Barron"	Present	Up to 0.7
H. serpens "Carroll"	Not present	Up to 0.6
H. serpens "Petrini"	Not present	Up to 0.8

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Notes on Corticiaceae (Basidiomycetes) XV

Some new species from Northern Europe

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Summary

Five new species are described from Northern Europe: *Amphinema diadema, Phlebia diaphana, Tubulicrinis confusus, T. evenii,* and *T. strangulatus.* Detailed descriptions and illustrations of the two first species are provided, while only Latin diagnosis are given for the taxa of *Tubulicrinis.*

When revising the genus *Tubulicrinis* for the flora-project The Corticiaceae of North Europe, three new taxa were found. These are here given formal diagnoses while detailed descriptions, illustrations and discussions will appear in volume 8 of the aforenamed flora. We also find it necessary to describe two new taxa which has long resided in our herbaria under provisional names.

TUBULICRINIS CONFUSUS Larss. & Hjortst. spec. nov.

Differt a Tubulicrine effugiente cystidiis obtusis, numquam subulatis vel mucronatis.

HOLOTYPUS: Norway. Hedmark, Liberget, on Picea. 1985-08-24. KHL 5921 (GB).
PARATYPI, selected: Norway. Hedmark, Liberget, on Picea. 1985-08-24. KHL 5926 (GB); Oppland, Øyer, Bårdsengsbekken, on Picea. 1979-09-22. Backe 1842 (GB). — Sweden. Dalsland, Gunnarsnäs, E of Svarvaretorpet, on Picea. 1976-10-23. KHL s.n. (GB). — Canada. Ontario, Gomphidius Bay, lake Timagami. 1936-09-01. R. Biggs, det L. Weresub as *T. fallax* ined. DAOM 95885 (DAOM, part in GB).

TUBULICRINIS EVENII Larss. & Hjortst. spec. nov.

Differt a Tubulicrine sororio sporis 6-7 x 2-2.5 μm et cystidiis proiectis, apicem globula resinosa.

HOLOTYPUS: Norway. Hedmark, Engerdal, on Pinus. 1981-07-29. Even Høgholen 35/81 (O). ISOTYPUS: (GB)
PARATYPUS: Sweden, Ångermanland, Junsele, NNW of Ruske, on Pinus. 1970-09-21. Hjm 4313 (GB)

Etymology: In honour of the eminent norwegian mycologist Even Høgholen who has contributed a never ending flow of new and rare species to the known flora of the Nordic countries.

TUBULICRINIS STRANGULATUS Larss. & Hjortst. spec. nov.

Differt a Tubulicrine boreali sporis 4-6 x 2.5-2.8 μm et basidiis tenuitunicatis vel leviter crassiusculis, non vel leviter amyloidibus.

HOLOTYPUS: Sweden. Västergötland, V:a Tunhem, Halleberg, Ovandalen, on Pinus. 1978-08-26. KHL 1966 (GB).
PARATYPI: Norway. Hedmark, Løten, Gitvola, on Picea. 1985-08-28. Hjm 16165 (GB); ditto Løten, Mikkelslykkeberget, on Picea. 1984-08-11. Høgholen 22/84 and 43/84 (GB,O). — Sweden. Småland, Åsenhöga, old spruce forest E of Kacklesjön, on deciduous wood. 1981-10-01. T. Hallingbäck (GB); Västergötland, Östad, S of Kleven, on coniferous wood. 1976-12-05. Hjm 7696 (GB); Ångermanland, Junsele, Åkerbränna in virgin forest, on trunk of Picea. 1970-09-20. Strid 7384 (S); Lycksele lappmark, Sorsele, Nalovardo near the top, on Picea trunk. 1983-08-29. KHL 4205 (GB).

AMPHINEMA DIADEMA Larss. & Hjortst. spec. nov. *Fig. 1*

Fructificatio effusa, laxe adnata, pellicularis, hymenium leve vel per cystidia pilosum, colore dilute fuscum vel luridum, margine byssoideus; systema hyphale monomiticum, hyphis tenuitunicatis, interdum incrustatis, hyalinis vel flavescentibus, fibulatis, 4-5 μm latis, acyanophilis; cystidia subfusiformia, obtusa, tenuitunicata vel crassiuscula, ad apicem incrustata, 50-70 x 4-7 μm; basidia clavata, 15-20 x 4.5-6 μm, 4-sterigmatibus; sporis subcylindricis, tenuitunicatis vel crassiusculis, levibus, 4.5-5 x 2.5(-2.8) μm, inamyloidibus, indextrinoidibus, acyanophilis.

HOLOTYPUS: Norway. Akershus, Nannestad, Tømte farm, on fencing. 1984-09-15. Hjm 14458 (GB).
PARATYPI: Norway. Akershus, Nannestad, Tømte farm, on fencing. 1980-09-22. Hjm 12129 (GB); ditto, Horna river by Hurdal lake, on Picea. 1978-09-20. Hjm 9873 (GB); ditto on Aconitum septentrionale. 1978-09-25. Hjm 9983 (GB). — Poland. Zakopane, Tatry National Park, on debris. 1973-09-17. Hallenberg & Larsson 2959 (GB). — Sweden. Ångermanland, Junsele, NNW of Ruske, near Ruskån, on Picea. 1970-09-21. Hjm 4294 (GB); Lule lappmark, Nattavaara, on Picea. 1910-09-08. Romell 2743, det Litschauer *Peniophora luteobrunnea* spec. nov. in herb. (S).

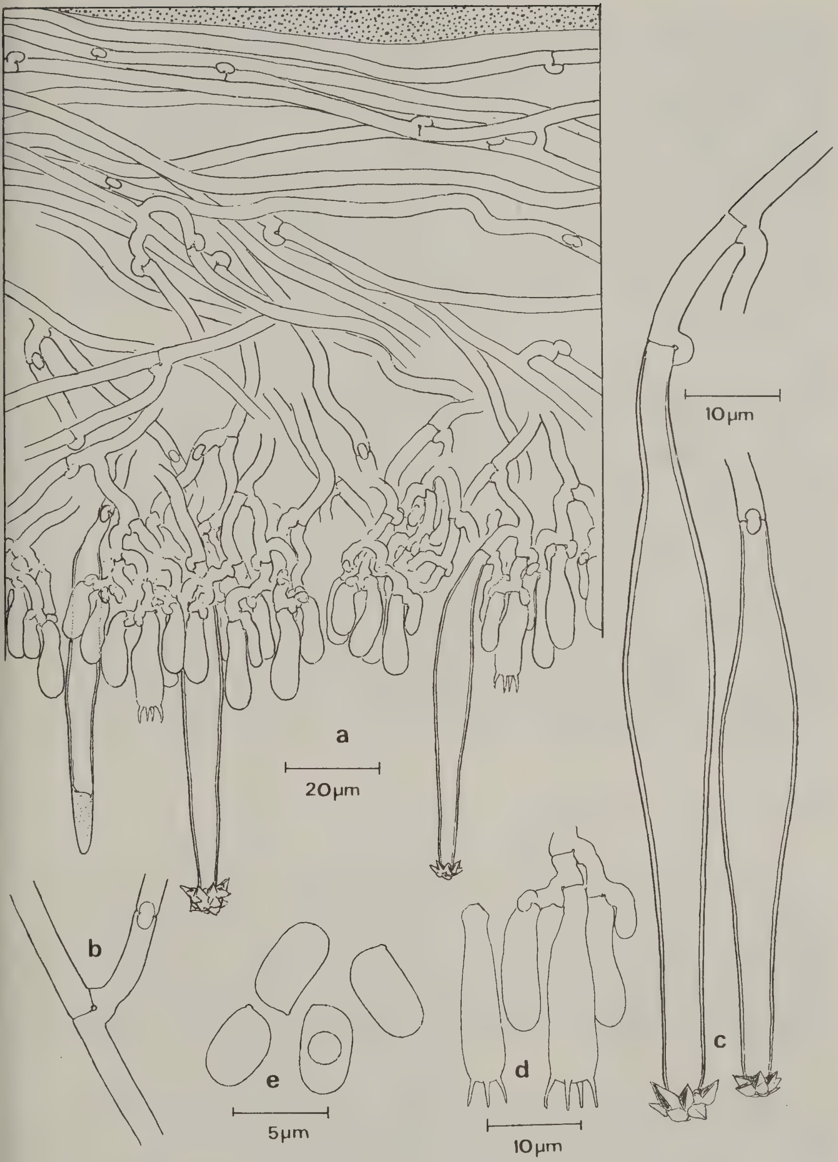
a
20µm
b
c
10µm
d
10µm
e
5µm

Fig. 1. *Amphinema diadema* a) section through fruitbody b) single subicular hypha c) cystidia d) basidia e) spores. — coll. Hjortstam 9983, del. John Eriksson.

Fruitbody loosely adnate, effuse, pellicular to softly membranaceous, pliable, strongly pilose from protruding cystidia, pale brown, sometimes with dirty yellow hyphal strands, margin narrow but often somewhat fibrous, paler than the fertile part, often more or less yellowish. *Hyphal system* monomitic, hyphae thin-walled, smooth or slightly encrusted, hyaline, or basal ones yellowish-brown, especially in KOH, as a rule 4-5 μm wide and with clamps at all septa, hyphae next to the substratum straight and often anastomosing. *Cystidia* numerous, at first thin-walled then with somewhat thickened walls, apical part encrusted, in fresh material often red-violet in Melzer's Reagent, fusiform to subfusiform, about 50-70 x 4-7 μm. *Basidia* commonly clavate and somewhat contracted towards the attachments of the sterigmata, 15-20 x 4.5-6 μm, with four sterigmata and a basal clamp. *Spores* narrowly ellipsoid, thin-walled or with very slight wall thickening, 4.5-5 x 2.5(-2.8) μm, inamyloid, indextrinoid, and acyanophilous.

Amphinema diadema at first seems to deviate from the current concept of *Amphinema*. The type, *A. byssoides* (Pers.:Fr.)John Erikss., has a light yellow, very loose and byssoid fruitbody composed of intertangled yellowish hyphae. The cystidia are numerous, septate, hypha-like, and finely encrusted. The other two species hitherto known, *A. tomentellum* (Bres.)M.P.Christ. and *A. arachispora* Burds. & Nakas., are very close to the type. There are several characteristics that *A. diadema* shares with these other species. We want to stress the overall basidial form and especially the morphology of the sterigmatal attachment. Sterigmata grow rather close to each other making their arrangement appear somewhat contracted. This character is found also in *Piloderma*. The size and shape of spores and hyphae show clear similarities and the light yellowish-brown hyphae, rarely seen among corticiaceous fungi, also point to a relationship. Another clue to the generic disposition is found in ecology. *A. diadema* grows on diverse substrata. The fruitbodies are loosely connected with the substrata and hyphal strands are occasionally seen. This indicates that *A. diadema* belongs to the litter-fungi, as does *A. byssoides.*

PHLEBIA DIAPHANA Parm. ex Larss. & Hjortst. spec. nov. *Fig. 2-3*

Phlebia subulata aemulans, differt fructificatione cornea et plus minus translucente.

HOLOTYPUS: RPSS Georgica. Hulo, Bacho, on Abies nordmanniana, ad caudicem prostatum in abieteto-piceto. 1963-10-03. Parmasto 16034 (TAA, Tartu).
ISOTYPUS: (GB).
PARATYPUS: Finland. Pohjois-Pohjanmaa, Tervola, Pisavaara National Park, on very strongly decayed and decorticated Picea. 1981-09-21. Kotiranta 3596/B (GB, H).

Fruitbody closely adnate to the substratum, in living stage subgelatinous, semitranslucent and mostly greyish-ochraceous, when dried about 0.5-1.5 mm thick, mostly tuberculate, hard to almost horny, cystidia not or hardly visible under a lens, in section stratified with the subicular tissue(s) darker, margin indistinct. *Hyphal system* monomitic, hyphae fairly narrow and densely agglutinated, about 1.5-2.5 μm wide, thin-walled but swelling and becoming gelatinized in KOH, with clamps, tissue more or less netlike in section with gelatinized matrix. *Cystidia* subulate, about 50-70 μm long and 6-7 μm wide in the middle part, thin-walled or in KOH with slight wall swelling, smooth, as a rule protruding 10-20 μm above the basidia. *Basidia* subclavate, 15-20(-25) x 3.5-4 μm, swelling slightly in KOH and

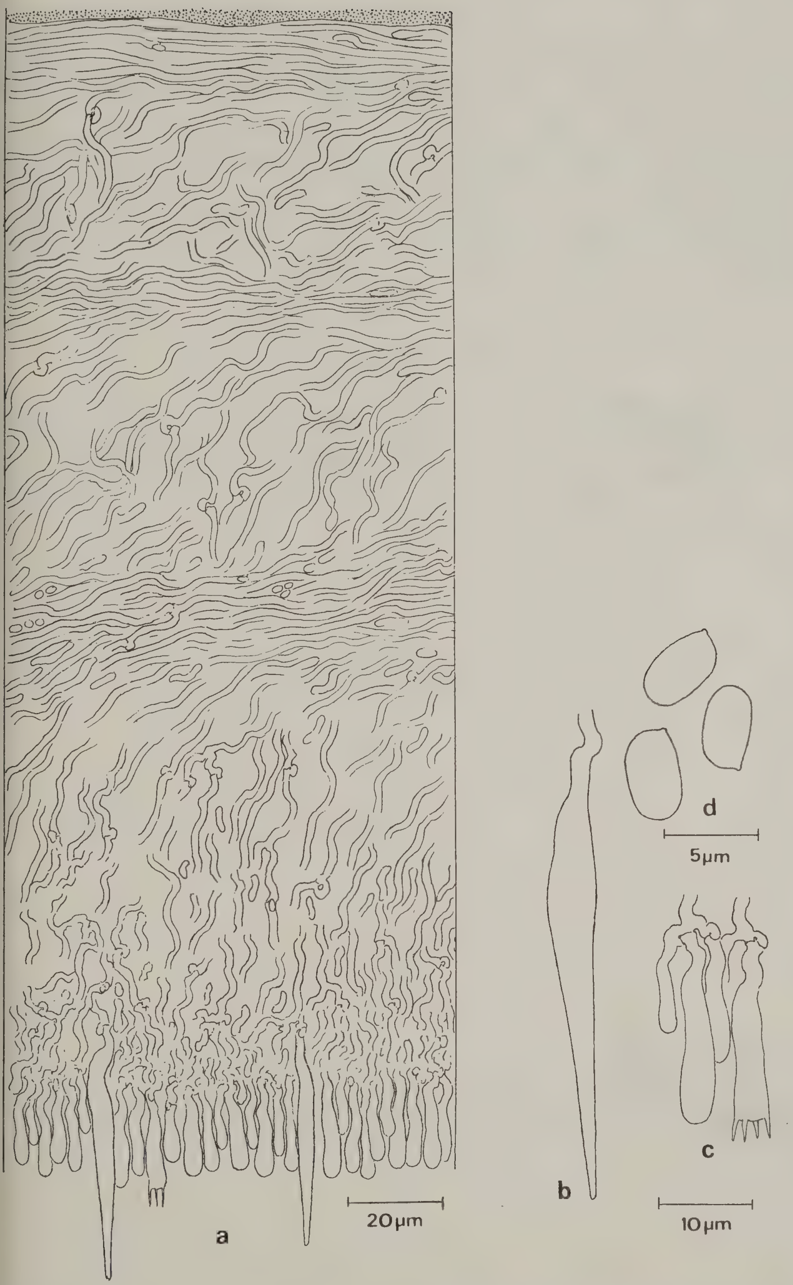
a
20µm
b
d
5µm
c
10µm

Fig. 2. *Phlebia diaphana* a) section through fruitbody b) cystidium c) basidia d) spores. — Holotype, del. John Eriksson.

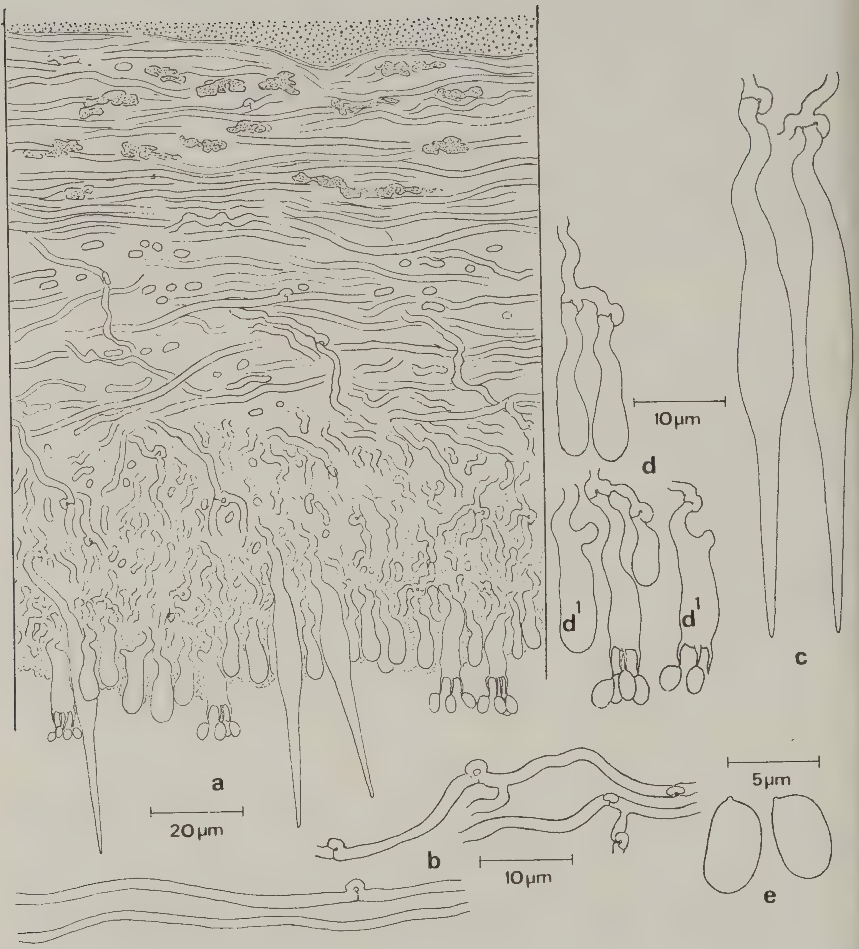
a
20 µm
b
10 µm
c
d
10 µm
d1
d1
e
5 µm

Fig. 3. *Phlebia diaphana* a) section through fruitbody b) subicular hyphae c) cystidia d) basidia d1) hooked basidia e) spores. — coll. Kotiranta 3596/B, del. John Eriksson.

sometimes distinctly hooked near the base, with four sterigmata and a basal clamp. *Spores* ellipsoid, 5-5.5(-6) x 3-3.5(-3.8) μm, thin-walled, hyaline, smooth, inamyloid, indextrinoid and acyanophilous.

With certainty a very rare species in Northern Europe, known long since as *Phlebia adsharica* Parm., but never formally published (see Eriksson et al., The Corticiaceae of North Europe, vol. 6 p. 1176, 1981). Its horny fructification makes it very similar to *Phlebia cornea* (Bourd. & Galz.) Parm. which however has totally different cystidia and spores. Microscopically it resembles *Ph. subulata* John Erikss. & Hjortst. but that species has a more or less loose consistency, never horny and semitranslucent.

Acknowledgments

We wish to acknowledge Dr. Richard P. Korf for kindly checking the English language, and Dr. Leif Ryvarden for reviewing the manuscript. Special thanks to Prof. John Eriksson who has patience with us during taxonomic discussions and for his never-ceasing interest in India-ink artistry.

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NOTICE

SYMPOSIUM: THE EXPANDING REALM OF YEAST-LIKE FUNGI

An international symposium on the perspectives of taxonomy, ecology, and phylogeny of yeasts and yeast-like fungi will be a satellite conference of the XIV International Botanical Congress, and will be held immediately after that Congress, 3-7 August, 1987, at Amersfoort, The Netherlands. A Second Circular has appeared, listing the Plenary Sessions, including a registration form, and providing information on Special Workshops, Contributed Posters (deadline for submission of poster abstracts is April 1, 1987), etc.

The Symposium is arranged by the Royal Netherlands Academy of Arts and Sciences and the Centraalbureau voor Schimmelcultures. The Organizing Committee consists of G. S. de Hoog (Baarn), M. Th. Smith (Delft), and A. C. M. Weijman (Baarn). The Advisory Board consists of L. R. Batra (U.S.A.), B. Kendrick (Canada), T. Nakase (Japan), F. Oberwinkler (F. R. Germany), and J. P. van der Walt (South Africa).

Copies of the Second Circular may be obtained through:

Dr. G. S. de Hoog
Centraalbureau voor Schimmelcultures
P.O. Box 273
3740 AG Baarn, The Netherlands

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TAXONOMY OF CORIOLOPSIS SPRUCEI COMB. NOV.

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ABSTRACT

Detailed observations on morphological and cultural characters of *Daedalea sprucei* Berk. are given and the taxonomy of this species is discussed. The species belongs to the genus *Coriolopsis* Murr. and a new combination is proposed accordingly.

Key words: *Daedalea sprucei*, morphology, culture, taxonomy.

While surveying the polypore flora of West Bengal, India, we made several collections of *Daedalea sprucei* Berk., which were found causing white rots on deciduous trees. We made detailed morphological and cultural studies of our materials and came to the conclusion that the species does not fit with the modern generic concepts of *Daedalea* Pers. Rather, it possesses many taxonomically important characters of the genus *Coriolopsis* Murr. In this paper our observations are presented, the taxonomy of the species is discussed, and a new combination of the species in the genus *Coriolopsis* is proposed.

MATERIALS AND METHODS

Observations were based on fresh specimens collected by the authors. Microscopic characters of the basidiocarps were studied from free hand sections mounted in 10% KOH and stained with 1% cotton blue. Cultures were studied following the methods of Nobles (1948) and Nobles et al. (1957). Oxidase reactions were tested by the Bavendamm method as described by Davidson et al. (1938) and the gum guaiac method as described by Nobles (1958). Voucher specimens and cultures are maintained in the Mycological Herbarium of the Bisva-Bharati University (VBMH) and one culture (VBMH 81781) is deposited in American Type Culture Collection (ATCC 56333).

DESCRIPTION OF BASIDIOCARPS

Coriolopsis sprucei (Berk.) Roy & Mitra, **comb. nov.**
≡ *Daedalea sprucei* Berk., Hook. J. Bot. 8: 236, 1856 (Basionym).

Basidiocarps perennial, broadly attached, pileate, pileus applanate, usually solitary, sometimes fused into lateral rows, hard and woody, 6-17 X 3-10 X 1-4 cm; upper surface reddish violet when fresh, brown on drying, turning blackish with age, azonate to faintly zonate, velvety when young, nodulose, crustose and rimosely cracking in old specimens, sometimes developing blue green algae on the rimose psart; margin thin to thick; context fibrous, brown, 0.2 to 1.5 cm thick; hymenial surface reddish violet when fresh, brown on drying, pores irregular, at times poroid, daedaloid or lamellate even in the same basidiocarp, pore tube up to 2 cm, or longer, slightly oblique, pores 5-7 per cm.

Hyphal system trimitic. (a) Generative hyphae 1.5-3 µm in diam, quite common, hyaline to pale, with clamp connections, thin to slightly thick-walled (Fig. 1), some sclerified (Fig. 2), more abundant in the lower context where they frequently appear in collapsed and twisted condition with short branches (Fig. 3); (b) skeletal hyphae 3.5-5.5 µm in diam, pale brown, thick-walled, lumina wide or occluded, sometimes encrusted, often with solid, beaded projections (Fig. 4), sometimes showing septa towards the apex (Fig. 5), rarely apically bifurcate (Fig. 6), often twisted and tape-like (Fig. 7); (c) binding hyphae 1.8-3 µm in diam, hyaline to pale brown, thick-walled to solid, with few branches (Fig. 8), scarce and found mainly in the lower context and dissepiments; basidia narrow clavate, 4-sterigmate, 12.5-16 X 3.5-4.2 µm in diam (Fig. 9); spores hyaline, thin-walled, short cylindric to ellipsoid, 4.5-5.6 X 2.5-3 µm (Fig. 10); cystidia abundant, thin- to slightly thick-walled, fusoid, usually hyaline, yellowish in the older part, apically encrusted in the form of a cap, crystals very often detached (Fig. 11).

Specimens studied: VBMH 81781* and 81782, growing on living *Shorea robusta* Gaertn. f.; VBMH 82783* on living *Ficus hispida* Lin.; VBMH 82784* and 82785, on fallen log of *Shorea robusta* Gaertn. f.

Rot: Associated with white rot.

DESCRIPTION OF CULTURES

Growth characteristics. Growth slow, covering the plate in six weeks. Advancing zone even, hyaline, appressed in a narrow zone of about 1 mm; mat at first white, thin, wholly floccose, soon becoming subfelty to

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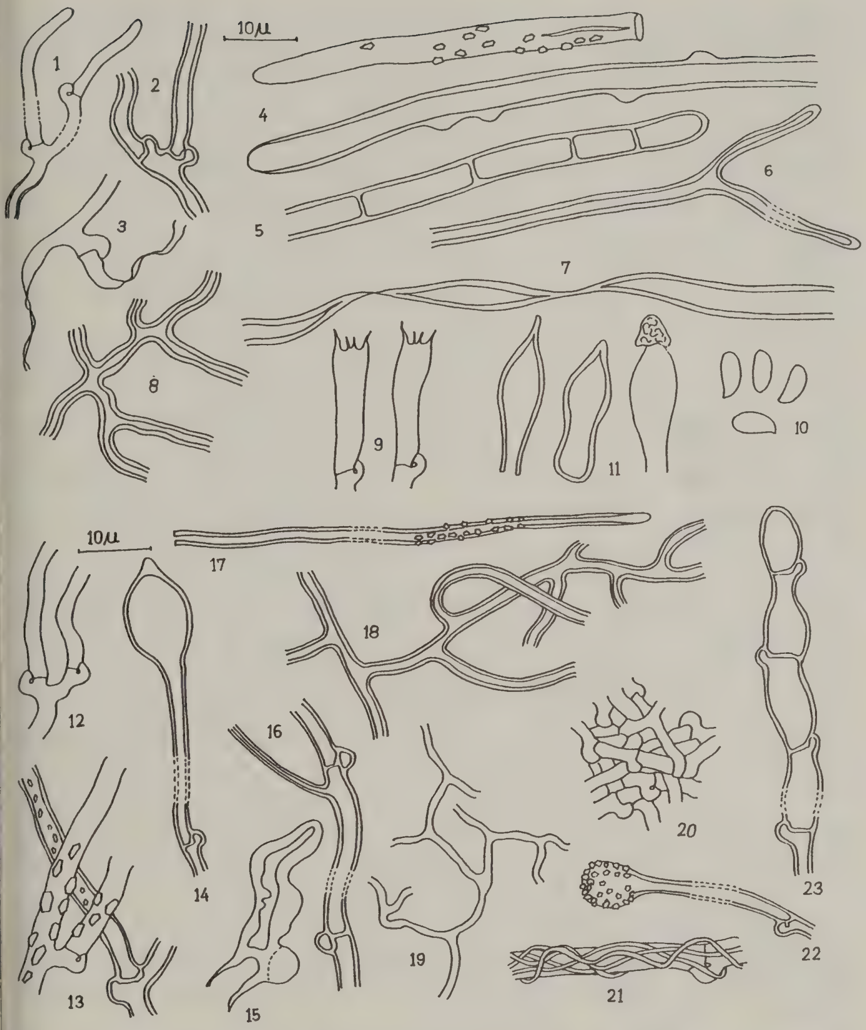
An asterisk (*) denotes a specimen from which culture was established for study.



Figs. 1-23. *Coriolopsis sprucei.* Figs. 1-11. Microscopic structures from basidiocarps. 1. Thin-walled to slightly thick-walled generative hyphae. 2. Sclerified generative hyphae. 3. Collapsed and twisted generative hyphae. 4. Sclerified hyphae with encrustation and solid beaded projections. 5. Skeletal hypha with septa at the apex. 6. Apically bifurcate skeletal hypha. 7. Twisted and tape-like skeletal hypha. 8. Binding hyphae. 9. Basidia. 10. Basidiospores. 11. Cystidia. Figs. 12-23. Microscopic structures from cultures. 12. Thin-walled hyphae with clamp connections. 13. Thin- to slightly thick-walled encrusted hyphae with clamp connections. 14. Allocyst. 15. Irregularly thickened apical cell with clamp connection. 16. Thick-walled hypha with clamp connection and much narrower branch. 17. Unbranched encrusted fibre hypha. 18. Branched fibre hypha. 19. Branched filiform fibre hypha. 20. Thin tissue of interlocked hyphae. 21. Thin-walled hypha with clamp connection spirally entwined by hair-like hyphae. 22. Apically encrusted cystidium. 23. Chlamydospores in a chain.

woolly felty and more condensed in the older part, fine zonations and striations appearing after 3 weeks when pinkish tinge also appears around the inoculum; reverse partly bleached; oxidase reactions positive but not strong with the Bavendamm test, mat white and floccose, 1.4-1.6 cm in diam on gallic acid and tannic acid agars in 7 days, and weak with the gum guaiac solution, faint blue colouration appearing after about 15 minutes.

Hyphal characteristics. Hyphae in the advancing zone with abundant bulging clamp connections, 1.2-3.3 µm diam (Fig. 12); aerial mycelium constituents: (a) hyphae as in the advancing zone, but wider (up to 4.6 µm in diam), thin- or thick-walled, sometimes encrusted with small and large crystals (Fig.13), occasionally slightly thick-walled, allocysts often beaked, up to 10.4 µm in diam (Fig. 14); sometimes apical cell irregular in outline and peculiarly thickened with highly refractive, irregular wall thickening (Fig. 15), occasionally developing much narrower branches about 0.8-1.3 µm in diam (Fig. 16); (b) fibre hyphae few but of various kinds, developing only in the older mat and also not before five to six weeks of growth, hyaline, often encrusted, 1.5-2.3 µm in diam, sometimes unbranched (Fig. 17), profusely branched (Fig. 18), or dichotomously branched, filiform and less than 1 µm in diam (Fig. 19); (c) a thin tissue of interlocking hyphae formed by extremely hyaline, short-celled, thin-walled, branched hyphae with clamp connections (Fig. 20), found on the upper surface of the media and just below the mat imparting toughness to that part; (d) hyphae hyaline, thin- to slightly thick-walled, with clamp connections, spirally entwined by very narrow, hair-like hyphae about 0.7-1 µm in diam, probably originating from the clamp connection below (Fig. 21); (e) cystidia abundant, thick-walled, apically encrusted, up to 9.2 µm wide (Fig. 22); (f) chlamydospores hyaline, slightly thick-walled, single or in chains, terminal or intercalary, always with a small clamp connection at base, of various shapes, ovoid, elliptical, or even cylindrical, 6.5-43 X 3.2-7.8 µm (Fig. 23).

Incompatibility system. The result of pairing of 20 monosporous cultures obtained from a fresh basidiocarp (VBMH 81781) shows the species to be tetrapolar with the following distribution of mating types among the spores.

A1 B1: 1, 5, 8, 16, 19, 20	A1 B2: 2, 10, 11, 14, 15
A2 B2: 6, 13, 17, 18	A2 B1: 3, 4, 7, 9, 12

Species code: 2, 3, 8, 13, 25, 26, 34, 36, 40, 46, 54, 60.

DISCUSSIONS

Basidiocarps of *D. sprucei* have been described by Bagchee (1958), Fidalgo (1961), Bakshi (1971), Reid (1976) and Ryvarden and Johansen (1980), and of these, the first and the third author described the species under the name *Trametes incerta* Curr. Ryvarden and Johansen (loc. cit.)

compared the holotypes of *D. sprucei* and *T. incerta* and considered them to be synonymous. The species has been studied in culture by Bakshi et al. (1970) and Stalpers (1978). Our observations agree broadly with those of the earlier workers, but in the present paper observations are given in greater detail. None of the previous workers mentioned the presence of encrustations on hyphae, sclerified generative hyphae and skeletal hyphae with thick-walled beaded projections on their walls within the basidiocarps of this species. Bakshi (loc. cit.) did not record fibre hyphae in culture, while Stalpers (loc. cit.) noted their occasional presence. We found fibre hyphae of various kinds in all the isolates, but they were few in number and also appeared after 5 to 6 weeks of growth. The different kinds of fibre hyphae, wide hyphae with clamp connections spirally twined by hair-like hyphae, encrusted cystidia, chlamydospores of variable forms and a thin tissue of interlocking hyphae formed just below the mat and on the upper surface of the media, are characteristic cultural features of the species not described by the previous workers.

Fidalgo (1961) found thick-walled brown basidiospores in the basidiocarps of *D. sprucei* and erected a genus *Phaeodaedalea* based on this species. But her observvation was not supported by other workers and also not by us. According to Reid (1976), the brown thick-walled spores "must either have been conidia produced by the fungus itself or the spores of another fungus parasitic in the hymenium." He also pointed out that as the spore characters and the hyphal system of *D. sprucei* are very similar to those of *Daedalea quercina* L. ex Fr., the type species of the genus *Daedalea* Pers. ex Fr., *D. sprucei* is to be best retained in the genus *Daedalea*. Pegler (1967) also treated *Phaeodaedalea* as synonymous with *Daedalea*.

According to the modern generic concepts of *Daedalea* (Aoshima, 1967; De, 1981; Mitra & Roy, 1984; Roy, 1982; Roy & Mitra, 1983, 1984), this genus includes species producing basidiocarps which have a white or brownish context, are trimitic in construction containing hyaline to subhyaline skeletal hyphae, develop thin- to thick-walled clamped hyphae within basidiocarps as well as in culture and some with irregularly thickened walls, cause brown rots and exhibit bipolar sexuality.

On the other hand, critical observations on the morphological, cultural and certain biological characters of *D. sprucei* reveal its close relationship with *Coriolopsis occidentalis* (Kl.) Murr., the type species of the genus *Coriolopsis* Murr. *C. occidentalis* produces basidiocarps with a brown context and a trimitic hyphal system (Fidalgo & Fidalgo, 1966; Van der Westhuizen, 1971; Wright et al., 1973) including subhyaline to brown skeletal hyphae, as also does *D. sprucei*. The cultural characters of *C. occidentalis* (Nobles, 1965; Van der Westhuizen, 1971; Stalpers, 1978) are also very close to those of *D. sprucei* as will be evident by comparing the species code of *C. occidentalis* which is 2, 3, 8, 35, 36, 38, (48) 50, 54, 60

(Nobles, 1965) with that of *D. sprucei* given above. Moreover, both the species cause white rots and show tetrapolar sexuality. Such great similarities between the two species regarding morphological, cultural and certain biological characters indicate a phylogenetic relationship. Therefore we conclude that *D. sprucei* should be transferred to the genus *Coriolopsis*.

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MYCOTAXON

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A NEW SPECIES AND NEW RECORDS IN THE LICHEN GENUS *XANTHOPARMELIA* (VAIN.) HALE (ASCOMYCOTINA:PARMELIACEAE)FOR NORTH AMERICA

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ABSTRACT: *Xanthoparmelia maricopensis* is described from the United States of America and Mexico. The new combinations *Xanthoparmelia neorimalis* (Elix & Armstrong) Elix & Nash and *Xanthoparmelia oleosa* (Elix & Armstrong) Elix & Nash are proposed and they are reported for the first time respectively from Mexico and from Mexico and the United States of America.

XANTHOPARMELIA MARICOPENSIS Nash & Elix, sp.nov.

Thallus adnatissimus, saxicola, 2-5 cm latus, flavescenti-viridis, lobis angustis sublinearibus, 1-2 mm latis, aetate rugosis, superne planis ad convexis, isidiatus, isidiis densis, cylindricis, aetate inflatis, simplicibus, aetate ramosis, 0.1-0.3 mm diametro, 0.1-0.8 mm altis, cortex superior 10-15 um crassus, stratum gonidiale 40-55 um crassum, medulla alba, 65-90 um crassa, cortex inferior 10-25 um crassus, subtus pallide castaneus, modice rhizinosus, rhizinis simplicibus, pallidis, apothecia ignota, thallo acidum usnicum, acidum pertusaricum, acidum norsticticum, acidum constipaticum, acidum protoconstipaticum, acidum hyposalazinicum et acidum connorsticticum continenti.

Thallus adnate to tightly adnate on rock, yellowish green, 2.0-8.0 cm broad; lobes sublinear, contiguous, convex, 0.5-2.5 mm wide; upper surface continuous, isidiate, the isidia developing branches and becoming inflated with darkened tips, occasionally becoming erumpent but not sorediate, 0.1-0.3 x 0.1-0.8 mm; lower surface plane, pale brown, moderately rhizinate, the rhizines pale brown. Pycnidia and apothecia lacking.

Chemistry: usnic, norstictic (major), hyposalazinic and connorstictic acids constant with the accessory fatty acids, pertusaric, constipatic and protoconstipatic acids.

Type: Crater Mountains along route 85, 425 m, Maricopa County, Arizona, United States of America, Nash 6059 (ASU, holotype; ANUC, BM, COLO, DUKE, F, LSU, MIN, NYBG, O and US isotypes).

Paratypes Examined

MEXICO. BAJA CALIFORNIA DEL NORTE: on basalt, 6 km W of Laguna Chapala, 750 m, Nash 12,981 (ASU, ANUC, COLO, DUKE, MIN, O, US); on granite, 50 km W of Mexicali on E slope of Sierra de Juarez, 600 m, Nash 4370 (ASU); BAJA CALIFORNIA SUR; on basalt, 5 km S of El Arco, 260 m, Nash 12,925 (ASU); on basalt, Sierra de la Gigante, 15 km W of Rosarita, 335 m, Nash 12,906 (ANUC, ASU); CHIHUAHUA: on rhyolite, 133 km NW of Chihuahua City along route 45, 1460 m, Nash 13,732 (ASU); COAHUILA, on siliceous rock, 34 km N of Saltillo along route 57, 1220 m, Nash 14,184 (ANUC, ASU, COLO, DUKE, MIN, O, US); DURANGO: on volcanic rock, 32 km S of Leon Guzman at Microndas Chocolate turnoff, 1400 m, Nash 13,973 [ANUC, ASU, BM, COLO, DUKE, EGAN, MIN, NYBG, O, US); SONORA: on granite, 8 km SE of Sonoyta in the Sierra Cubart, 365 m, Nash 11,916 (ANUC, ASU); on basalt, 34 km W of Sonoyta along route 2,365 m, Nash 11,911 (ANUC, ASU, COLO, O, US).

UNITED STATES OF AMERICA, ARIZONA: Cochise Co., west side of Harris Mountain on east side of Chiricahua Mountains, 1470 m, Nash 22,624 (ANUC, ASU); Gila Co., 12 km SSE of Government Hill near Roosevelt Dam, 910 m, Nash 20,847 (ANUC, ASU); Maricopa Co., Sierra Estrella Regional Park, 32 km WSW of Phoenix 490 m, Nash 5546 (ANUC, ASU COLO, DUKE, MIN, US); Mohave Co., 43 km E of Kingman along route 66 near Hackberry, 1070 m, Wetmore 14,902 (MIN), Pinal Co., Picacho Peak State Park, NE slope of Picacho Peak, 700 m, Nash 6160 (ANUC, ASU, COLO, EGAN, NYBG, O, US); Yavapai Co., Joshua Tree Parkway along route 93 ca. 19 km NW of junction of routes 93 and 71, 850 m, Nash 6356 (ASU); CALIFORNIA; San Bernardino Co., 3 km SW of Parker Dam near the Colorado River, 182 m, Nash 8461 (ANUC, ASU); San Drego Co., along interstate 8 at Ocotillo, 640 m, Nash 7044 (ANUC, ASU); NEW MEXICO: Dona Ana Co., along route 70 near San Agustin Pass in Organ Mountains, 24 km E of Las Cruces, 1830 m, Wetmore 14,451 (MIN); Lincoln Co., 8 km NW of Corrizo along route 380 adjacent Valley of Fires State Park, 1580 m, Nash 22,445 (ASU); San Juan Co., Chaco Canyon National Monument just S of Casa Rinconada ruins, 1920 m, Nash 16,370 (ASU); NEVADA: Clark Co., Atlatl Rock area, Valley of Fire State Park, 1370 m, Hale 52,109 (US); TEXAS: Brewster Co., Big Bend National Park in foothills near Green Gulch, 1550 m, Wetmore 18,425 (MIN); UTAH: Grand Co., 10 km SW of Oowah campground adjacent LaSal Mountains, 2225 m Hale 51,496 (US); Washington, Zion National Park at the bottom of Rim Canyon Trail, 1320 m, Nash 15585 (ASU).

As this taxon is characterised by the pale lower surface, the development of isidia and the production of norstictic acid in the medulla it has previously been identified as *Xanthoparmelia dierythra* (Hale) Hale (Nash and Zavada, 1977), a species initially described by Hale (1964). However it is now clear that *X. maricopensis* differs both chemically and morphologically from *X. dierythra*. Chemically *X. maricopensis* consistently contains trace quantities of hyposalazinic acid in addition to norstictic and connorstictic acids which are also present in *X dierythra*. Furthermore, the accessory fatty acids have not been found in *X. dierythra*. Morphologically these two species differ in several ways. The thallus of *X. dierythra* is typically adnate and the lobes flat whereas the thallus of *X. maricopensis* is tightly adnate and the lobes convex, a feature that is especially prominent in diminutive lobed, desert specimens. The isidia of *X. dierythra* are uniformly narrow (ca. 0.1 mm in diameter) and cylindrical, while those of *X. maricopensis* are larger (up to 0.3 mm in diameter) and usually inflated towards the apices, a feature that makes the isidia appear globose in some specimens. In both species the isidia become branched with age, but the initial branching of the isidia in *X. dierythra* occurs more or less at right angles to the thallus surface whereas in *X. maricopensis* branching usually occurs parallel to the upper surface of the thallus.

These two species exhibit different geographical distributions in North America. *Xanthoparmelia dierythra* is known from Minnesota, Wisconsin and South Dakota (Hale, 1964) and it is herein reported from Utah (Grand Co.: La Sal Mountains below Oowah Lake, 2440 m, Nash 20,924B(ASU); and San Juan Co.: Devil's Canyon, 26 km S of Monticello, 2300 m, Nash 14,940 (ANUC, ASU). In contrast, *X. maricopensis* has a more southerly distribution pattern (California to Coahuila) that is essentially allopatric with the pattern of *X. dierythra*. Within the Sonoran Desert *X. maricopensis* can be readily distinguished from the other isidiate species on the basis of chemistry: *X. kurokawae*, *X. mexicana*, *X. plittii* and *X. weberi* containing respectively psoromic, salazinic, stictic and hypoprotocetraric acids as their major secondary metabolites. Furthermore, *X. weberi* normally has wider lobes than *X. maricopensis* (Nash and Zavada 1977), but the lobe width of *X. maricopensis* is indistinguishable from the other species. Unfortunately the isidial characteristics have not been fully investigated in all species and consequently the degree to which morphological divergence parallels the known chemical divergence cannot be elaborated at this time.

NEW COMBINATIONS AND RECORDS OF *XANTHOPARMELIAE* FOR NORTH AMERICA

Xanthoparmelia neorimalis (Elix & Armstrong) Elix & Nash, comb. nov. Basionym: *Parmelia neorimalis* Elix & Armstrong, Aust.J.Bot., 31, 475 (1983). MEXICO, BAJA CALIFORNIA DEL NORTE; 21 km W of Camp Progresso, Nash 47906 (ASU).

Xanthoparmelia oleosa (Elix & Armstrong) Elix & Nash, comb. nov. Basionym: *Parmelia oleosa* Elix & Armstrong, Aust.J.Bot., 31, 478 (1983). MEXICO. SINALOA: 27 km NE of Choix, oak-pine forest, 1280 m, Nash 12,205 (ANUC, ASU); UNITED STATES OF AMERICA. ARIZONA: Santa Cruz Co., along route 289 just south of Pena Blanca Lake in the Coronado National Forest, 1160 m, Nash 6108 (ASU).

Acknowledgements

We thank Mr. D. Verdon for assistance with the Latin description and Mr. B. Ryan for initial specimen organization and Drs. M.E. Hale and C.M. Wetmore for access to collections. This research was supported by US-Australia Cooperative Science Grant Int 8412745.

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PSEUDOPEZICULA (HELOTIALES, PEZICULOIDEAE), A NEW DISCOMYCETE GENUS FOR PATHOGENS CAUSING AN ANGULAR LEAF SCORCH DISEASE OF GRAPES ("ROTBRENNER")

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SUMMARY

Pseudopeziza tracheiphila Müll.-Thurg., causal agent of the grape disease termed "Rotbrenner" in the European literature, an 8-spored species, and its 4-spored American counterpart, **Pseudopezicula tetraspora** n.sp., constitute a new genus, **Pseudopezicula.** Though it has long been recognized that the European species did not belong in the genus **Pseudopeziza,** its assignment here to the Peziculoideae is warranted by its asci (with their highly characteristic apical mechanism), ascospores, paraphyses, and pathogenesis. Unlike other members of the Peziculoideae which attack woody stems and branches, these species occur on leaves, mostly in association with vascular elements. **Pseudopezicula tracheiphila** is a new combination, and a discussion is provided of its anamorph, **Phialophora tracheiphila** comb. nov. The American species is shown to have binucleate ascospores, and like its European counterpart to attack not only cultivated and wild species and hybrids of **Vitis,** but also **Parthenocissus** (Vitaceae).

KEYWORDS: **Pseudopezicula**, **Pseudopeziza**, Rotbrenner, angular leaf scorch disease of grapes, Peziculoideae.

HISTORY AND PREVIOUS TAXONOMY

Over 80 years ago the Swiss botanist Herman Müller-Thurgau (**1903**) described a serious disease of cultivated grapes reported under various common names, particularly as "Rotbrenner." Müller-Thurgau described and carefully illustrated the development of the pathogen and its association with the vascular elements of infected leaves. He studied the fungus in hanging-drop cultures, on gelatin-solidified media, and on leaves. From infected leaves collected in the autumn and stored dry in the laboratory, he produced the fruiting bodies of the causal agent the following spring after a few days of incubation in moist chambers. The fungus was an erumpent discomycete forming tiny, densely aggregated apothecia, (130-) 250 (-400) µm in diameter, 95-125 apothecia per cm^2, mostly on the lower surface of leaves. On the upper surface he observed fewer than 1 to rarely 20 apothecia per cm^2.

Müller-Thurgau described the fungus in detail, gave full measurements of microscopic features, and provided five superb plates. One illustrates the diseased leaves (in color), the other four provide the microscopic details of pathogenesis, of his cultural studies, and of the apothecia, including the asci, ascospores, and paraphyses, as well as of a conidial or spermatial anamorph. No separate, formal diagnosis or description appeared, though the fungus was formally proposed there as a new species (Müller-Thurgau, **1903**, p. 31), **Pseudopeziza tracheiphila**. The name was overlooked by P. Sydow in the lists of new names and new combinations which he regularly published in Just's Botanischer Jahresbericht from 1895 to 1918, even though the journal in which it was published was regularly scanned by Sydow. Saccardo and Saccardo (**1906**), in the **Sylloge Fungorum**, did catalogue this species, attributing it to Müller-Thurgau, citing the page and plate reference, but indicating "absque diagnosi." From a nomenclatural viewpoint, some might wish to argue that the name dates from its treatment in the **Sylloge Fungorum**, where a formal description appears. We, however, hold that the 1903 treatment is in large part a description of the fungus (far beyond the brief paragraph in the **Sylloge**), and that the name **Pseudopeziza tracheiphila** validly dates from 1903.

Placement of the causal agent of this disease in the genus **Pseudopeziza** Fuckel was understandable by the taxonomic standards at the turn of the century. The genus was recognized for a variety of leaf and stem fungi with small, dark-colored, erumpent apothecia on living and dead host tissues. The genus was usually placed in the Dermateaceae. Refinement of the taxonomy of inoperculate discomycetes over the years has pointed to the isolated position this species occupies in **Pseudopeziza.** It was catalogued in **Pseudopeziza** by Boudier (**1907**) shortly after publication, and similarly treated by Rehm (**1912**), to whom it was unknown except by description. In a major taxonomic revision of the inoperculate discomycetes Nannfeldt (**1932**), who also knew the species only from Müller-Thurgau's description and illustrations, excluded it from **Pseudopeziza**, indicating it to be of doubtful position. In his monographic treatment of the Pseudopezizoideae sensu Nannfeldt, Schüepp (**1959**) noted that the apothecial structure and form of the asci differ so notably from species of **Pseudopeziza** that Müller-Thurgau's species must be excluded, and scarcely belongs in the family Dermateaceae. Other major European discomycete workers, F. von Höhnel, R. W. G. Dennis, M. Moser, and M. Svrček, have apparently not published on this species.

Rotbrenner or its incitant, **Pseudopeziza tracheiphila**, has been frequently reported in continental Europe and in the adjacent grape-growing regions of Turkey and Algeria as shown on the CMI Distribution Maps of Plant Diseases (Anon., **1968**), and is also reported from southern Russia (Levadoux, **1944**). A single, brief report from Brazil (Gobbato, **1937**), also noted on the CMI maps, does not indicate whether only symptoms were observed or whether apothecia were seen. Recently the disease has been reported for the first time in North America, in New York State (Pearson, et al., **1986**).

We used the moist-chamber technique reported by Lehoczky (**1966**), who, like Müller-Thurgau, used overwintered leaves, but substituted fresh, infected leaves since it had been discovered that apothecia can be produced from the New York material without overwintering. Later experiments with European material confirms that the same is true there. Apothecia will also form saprophytically on steam-sterilized leaves of a wide variety of host plants in Europe, including **Acer**, Castanea, Cornus, Corylus, Crataegus, Fagus, Ligustrum, Rubus, Salix, and **Urtica** (Hahn, **1957**).

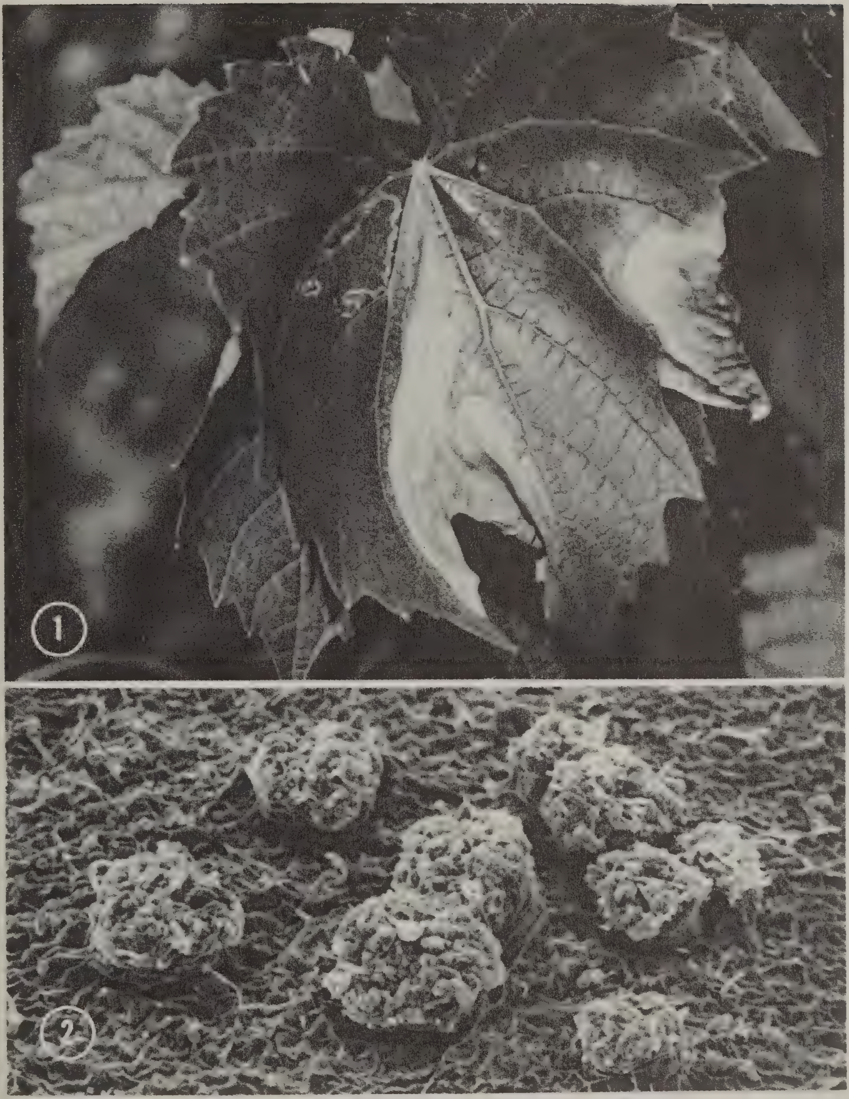
ON THE APOTHECIA OF THE CAUSAL AGENTS OF ANGULAR LEAF SCORCH

Study of material from New York has revealed that, though angular leaf scorch symptoms (FIG. 1) are virtually indistinguishable from those of European Rotbrenner specimens, all North American material produces even smaller apothecia (FIG. 2) with 4-spored asci (FIGS. 5, 8), while the European material is 8-spored (FIGS. 6, 7). It is our belief that two distinct species should be recognized.

We are in complete agreement with Nannfeldt (**1932**) and with Schüepp (**1959**) that the European species (as well as its American counterpart) cannot be accommodated in **Pseudopeziza**, differing from the type species of that genus, **P. trifolii** (Biv.-Bern.) Fuckel, in many fundamental characters. The exceptionally simple apothecial structure of the tiny apothecia, in which often only a few asci mature and produce ascospores, gives few clues to the relationships of this discomycete.

The ascospores themselves, the asci, and the paraphyses of these two species (FIGS. 5-8) possess an array of characters which seem to point unequivocably to a close relationship to **Pezicula** Tul. & Tul., type genus of the subfamily Peziculoideae, a group of parasites of higher plants. In nearly all treatments this subfamily has been placed in the Dermateaceae, though in the recent revision by Hennebert & Bellemère (**1979**) it is a subfamily of the Drepanopezizaceae. In **Pezicula** ascospores are large, frequently somewhat flattened on one side and often slightly bent, and are either non-septate or develop thin septa late in ascospore maturation. Asci with 4 or 8 spores are common. The asci, too, are typically broad and very large. Good illustrations of ascus and spore characters are given by Dennis (**1974**) and Wollenweber (**1939**). Paraphyses are frequently deformed and branched at their apices (propoloid), which may give a powdery or pruinose appearance to the hymenium when viewed under the hand lens.

Asci in **Pezicula** and other members of the Peziculoideae are provided apically with a highly characteristic spore-discharge mechanism which shows a



FIGS. 1-2. **Pseudopezicula tetraspora**. 1. Angular leaf scorch symptoms on leaves of **Vitis** interspecific hybrid cv. 'Aurore.' 2. SEM photo of apothecia erumpent from lower surface of grape leaves, X140.

remarkable variation in its reaction to iodine. The mechanism becomes intensely blue (termed "J+ by Ascomycete workers) in aqueous IKI or Melzer's Reagent if pretreated with 2%-10% aqueous KOH (or NaOH, but not NH_4OH) (FIGS. 7 D-E, 8 E), but remains colorless in such reagents if mounted from fresh material or in water rehydration (Minks, **1881**; Kohn & Korf, **1975**; Nannfeldt, **1976**; Rossman, **1980**). Only in the genus **Dermea** Fr. (Dermateoideae) and in scattered species in other genera of the discomycetes (Baral, **1986**) is such a KOH-pretreatment phenomenon reported.

Though all these microscopic characters of **Pezicula** are shared by the two leaf scorch pathogens, two features notably differ. The apothecia of **Pezicula** are also densely gregarious, but form instead somewhat larger apothecia 0.3-1.0 (-3.0) mm in diameter erumpent from the bark of trunks or branches of woody hosts or stems of **Rubus** or **Rosa**, not erumpent from leaf tissue. Species of **Pezicula** and of two other genera of the Peziculoideae, **Ocellaria** (Tul. & Tul.) Karst. and **Habrostictis** Fuckel, produce **Cryptosporiopsis** conidiomata. No such anamorph is associated with the grape-leaf pathogens.

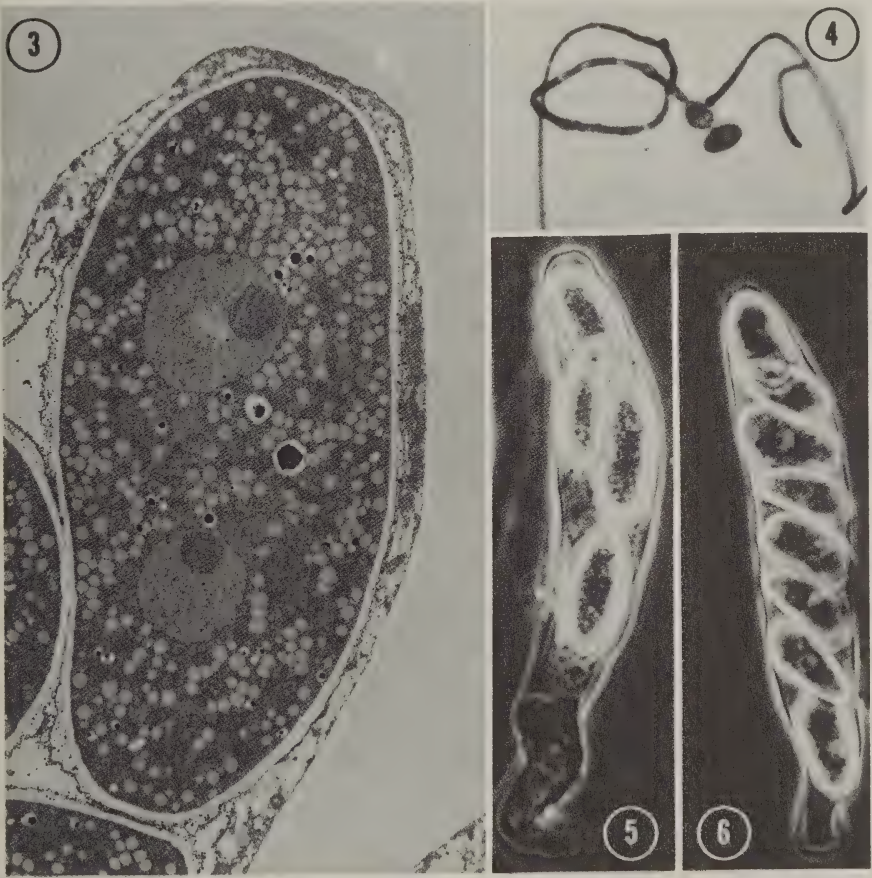
Because the angular leaf scorch and Rotbrenner fungi have no real affinity to **Pseudopeziza**, but belong instead to the Peziculoideae, a new genus is proposed here, the generic name reflecting both the 'old' generic name **Pseudopeziza**, under which the European species has long passed, and its closest relative, **Pezicula**.

PSEUDOPEZICULA Korf, gen. nov.

Apothecia minuta, sessilia, gregaria, ex textura folii erumpentia, plerumque hypophylla, cum venis saepe consociata, in maculis angularibus folii venis majoribus circumscriptis, disco aspectu gelatinoso, cellulis excipularibus hyalinis, angularibus vel prismaticis, ascis inoperculatis, late clavatis, poro iodo soluto madefacto colorem caeruleum ducente non nisi in KOH aquoso prius tractato, ascosporis magnis, ellipsoideis, multiguttulatis, in speciebus 8-sporis uninucleatis, in speciebus 4-sporis binucleatis, paraphysibus plerumque propoloideis, statu conidico ad ***Phialophoram*** *referendo, collariculis tenellis sed definitis praedito.*

Typus: **Pseudopezicula tetraspora** Korf, Pearson & Zhuang.

Apothecia minute, sessile, gregarious, erumpent from leaf tissue, usually hypophyllous, often associated with the veins, on angular leaf spots delimited by major veins, disc appearing gelatinous, whitish to faintly colored; excipular cells hyaline, angular to prismatic; asci inoperculate, broad clavate, pore blue in iodine only



FIGS. 3-6. **Pseudopezicula** spp. 3-5. **P. tetraspora.** 3. TEM photo of ascospore showing binucleate condition, with nucleoli clearly distinguishable, X approx. 4000. 4. Germinated ascospore showing nearly spherical, lateral vesicle ("secondary spore") which has germinated by two, coiling germ tubes, X 280. 5. 4-spored ascus, phase contrast, X 620. 6. **P. tracheiphila,** 8-spored ascus, uninucleate condition and nucleoli best observed in third, fifth, and seventh spores from apex, phase contrast, X 620.

after pretreatment in aqueous KOH; ascospores large, ellipsoid, multiguttulate, uninucleate in 8-spored species, binucleate in 4-spored species, germinating by production of a spore-like vesicle which in turn gives rise to one or more germ tubes or conidiophores; paraphyses usually propoloid; anamorph referable to **Phialophora**, with delicate but pronounced collarettes.

The European species was elegantly described by Müller-Thurgau (**1903**), but the following brief description is provided, based upon our observations.

PSEUDOPEZICULA TRACHEIPHILA (Müll.-Thurg.) Korf & Zhuang, **comb. nov.**
= **Pseudopeziza tracheiphila** Müll.-Thurg., Centralbl. Bakteriol., 2 Abth., **10**: 31. 1903. (Neotype designated below.)

Anamorph: **PHIALOPHORA TRACHEIPHILA** (Sacc. & Sacc.) Korf, **comb. nov.**
= **Botrytis tracheiphila** Sacc. & Sacc., Syll. Fung. **18**: 157. 1906. (Neotype designated below.)

FIGS. 6, 7.

Apothecium pulvinate to turbinate, sessile, up to 0.6 mm in diam when fresh, erumpent from leaf tissue, mostly hypophyllous; hymenium whitish when fresh, pale brown when dry; receptacle surface partially covered by the torn host tissue. **Ectal excipulum** of textura angularis, with marginal tissue of textura angularis to textura prismatica, cells isodiametric to somewhat rectangular towards the outside, 8.5–20.5 μm in diam, subhyaline to pale yellowish in the outermost layer, hyaline within, 30–37 μm thick at the flanks and ca. 12–17 μm thick at the base; **medullary excipulum** of mixed textura angularis to textura intricata, cells hyaline; **subhymenium** indistinguishable; **hymenium** ca. 105–130 μm thick. **Asci** inoperculate, 8-spored, broadly clavate with a tapered base, J+ in Melzer's Reagent with KOH-pretreatment, J- without KOH-pretreatment, 115–145 × 18–28 μm. **Ascospores** ellipsoid, flattened on one side, uninucleate, hyaline, guttulate, 19.8–25.7 × 9.3–14.0 μm, producing a spore-like **vesicle** on germination which gives rise to one or more germ tubes or conidiophores. **Paraphyses** filiform, septate, hyaline, branched and curved or slightly deformed at the apex, 2.2-2.7 μm wide. **Phialophora tracheiphila** anamorph with colonies white in malt agar medium, mycelium partially immersed; conidiophores macronematous, hyaline, septate, short, coarser than the vegetative hyphae; conidiogenous cells monophialidic, lageniform, sometimes slightly curved, with well-defined but very thin-walled collarettes; conidia ellipsoid, hyaline, unicellular, guttulate, ca. 2.0-3.7 x 1.4-1.9 μm.

NEOTYPES: The type specimen of this species is apparently lost, since Müller-Thurgau's herbarium is unknown (Stafleu and Cowan, 1981; E. Müller, personal communication). We designate here as the neotype specimen of **Pseudopeziza tracheiphila** material collected by our colleagues in Switzerland. NEOTYPE: H. Schüepp & M. Bodmer, on leaves of **Vitis vinifera** cv. 'Blauburgunder,' Seemühle, Walenstadt, Switzerland, IX. 1985, CUP-61782. Cultures were made from another European collection (CUP 61766) and are being sent to the Centraalbureau voor Schimmelcultures, Baarn, for deposit. As NEOTYPE specimen for the name **Botrytis tracheiphila** Sacc. & Sacc., a dried-down culture derived from CUP 61766 is hereby designated: R. Pearson, cultured from leaves of **Vitis vinifera**, Luxembourg, IX. 1985, CUP 61784.

NOTES: The species attacks the cultivated grape, **Vitis vinifera**, as well as several other species and interspecific hybrids of **Vitis**, and two other species of the Vitaceae, **Parthenocissus quinquefolia** and **P. tricuspidata** (Galet, 1977).

The North American species we describe here also attacks not only cultivars of **Vitis vinifera** (noted on the cultivars 'Chardonnay' and 'White Riesling'), but also cultivars of interspecific **Vitis** hybrids (noted on 'Aurore,' which is particularly susceptible (FIG. 1), as well as on 'Cayuga White,' 'De Chaunac,' 'Rougeon,' 'Suffolk Red,' and 'Vignoles'), on a wild species (**Vitis riparia**), and, in hedgerows adjacent to grape vineyards, on Virginia Creeper, **Parthenocissus quinquefolia**, a member of the Vitaceae (Pearson, et al., 1986). It is described here as a new species, and is the type species of **Pseudopezicula**.

PSEUDOPEZICULA TETRASPORA Korf, Pearson & Zhuang, **sp. nov.**

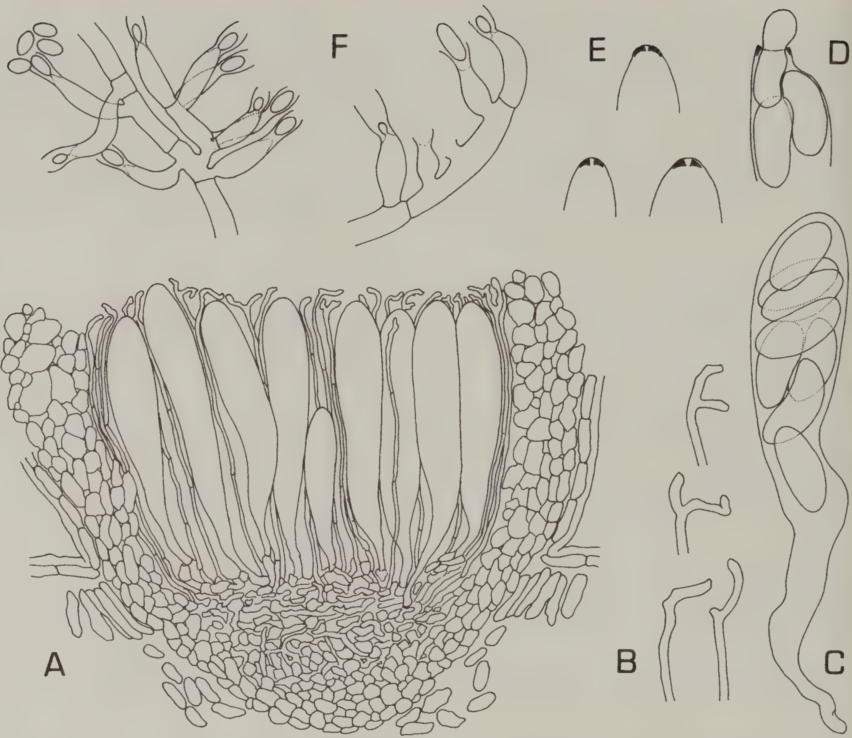


FIG. 7. **Pseudopezicula tracheiphila.** A. Transverse section of apothecium. B. Four paraphysis apices. C. Ascus and ascospores. D. Apex of ascus with one spore caught in ascus pore. E. Three ascus apices showing blueing reaction in Melzer's Reagent after KOH-pretreatment. F. **Phialophora tracheiphila** anamorph from culture. All drawn with the aid of a drawing tube from CUP 61766. A-C from cotton-blue lactic-acid mounts, D-F from Melzer's Reagent mounts. A, X 250; B-E, X 500; F, X 1000.

Anamorph: **Phialophora** sp. (unnamed here)

(FIGS. 1-5, 8)

Apothecia eis ***Ps. tracheiphilae*** *similia, sed minora (plerumque 0.1-0.3 mm diam), ascis 4-sporis, ascosporis binucleatis, 24.2-32.5 x 11.0-14.7 μm.*

Holotypus: R. Pearson, on leaves of **Vitis** hybrid cv.

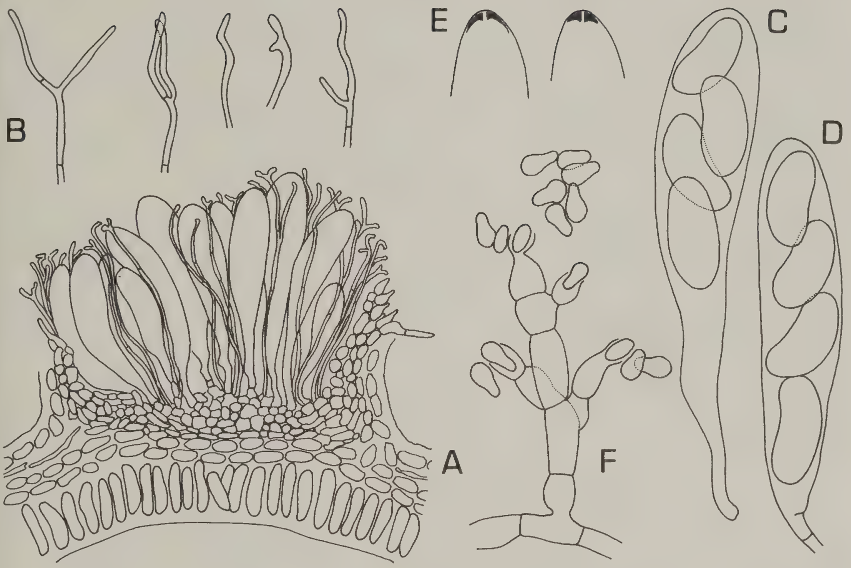


FIG. 8. **Pseudopezicula tetraspora**. A. Transverse section of apothecium. B. Five paraphysis apices. C, D. Asci and ascospores. E. Two ascus apices showing blueing reaction in Melzer's Reagent after KOH-pretreatment. F. **Phialophora** anamorph from culture. All drawn with the aid of a drawing tube, D from CUP 61781 on **Parthenocissus quinquifolia**, all others from holotype on **Vitis** cv. 'Aurore.' A-D, F from cotton-blue lactic-acid mounts, E from Melzer's Reagent mounts. A, X 250; B-E, X 500; F, X 1000.

'Aurore,' Watkins Glen, NY, 8. X. 1985, placed in moist chamber Oct. 11, 1985, and harvested Oct. 15, 1985, CUP-61765. (Isotypes to be issued in Korf & Gruff, Discomycetes Exsiccati.)

Apothecia pulvinate to turbinate, sessile, (0.04-) 0.1-0.3 (-0.43) mm in diam when fresh, erumpent from leaf tissue, hypophyllous, intramesophyllous; hymenium whitish to pale brown when fresh, whitish to light brown when dry; receptacle surface surrounded by the torn host tissue except at the margin. **Excipulum** thin, thicker in culture, not clearly differentiated in ectal, medullary, or subhymenial layers, of textura angularis to textura prismatica, margin only of 1 to 2 cell layers, with very short, tapered, non-septate or occasionally 1-septate protrusions from the outermost cells. **Asci** inoperculate, 4-spored (a few 5-spored asci noted), broadly clavate, with an elongate, tapered base, pore J+ in Melzer's Reagent with KOH-pretreatment, J- without KOH-pretreatment, 80–100 × 20–22 μm. **Ascospores** ellipsoid, flattened on one side or even subreniform, hyaline, biguttulate, binucleate, (20.9–) 24.2–32.5 × (10–) 11.0–14.7 μm, producing a spore-like vesicle on germination from which arise one or more germ tubes. **Paraphyses** filiform, septate, hyaline, branched in the middle or at the apex, the apex curved or irregularly deformed, ca. 2.0–2.5 μm wide. **Phialophora** anamorph with colonies on malt agar medium white to yellowish when old, mycelium partially immersed; conidiophores macronematous, hyaline, septate, short, coarser than the vegetative hyphae; conidiogenous cells monophialidic, legeniform, with well-defined but thin-walled collarettes; conidia pyriform to ellipsoid with one end narrower, hyaline, unicellular, guttulate, 3.5–5.5 × 2.0–2.3 μm.

NOTES: The ascospores of this species are regularly binucleate (Fig. 3), and since there is no evidence of any disintegrating ascospores, in all likelihood the ascospores are binucleate at the time they are delimited, much as in **Neurospora tetrasperma** Shear & Dodge. We have no TEM photographs of the very rare 5-spored asci we have observed (only four such asci have been noted in our light-microscopy work, and two of the spores in such asci appear smaller, and are presumed to be uninucleate). Single-spore cultures derived from the holotype collection are being deposited in the American Type Culture Collection, Rockville, Maryland.

ON "BOTRYTIS" TRACHEIPHILA

When Müller-Thurgau (**1903**) reported his studies, he also found an anamorph, which he illustrated but did not name, indicating that it resembled the conidial states reported by Brefeld (**1891**) for "**Mollisia cinerea** (Batsch)" and "**Pseudopeziza astrantiae** (Niessl)." Those illustrations do, in many ways, recall the anamorph that was illustrated arising on hyphae, from the (ascogonial?) coils, and from germinating ascospores. In neither author's illustrations is there, however, sufficient detail to ascertain how spores are produced. Some spores appear to be borne directly on the mycelium, while others are produced on somewhat tapering structures, often clustered, that may be phialides. We judge from Hennebert and Bellemere's (**1979**) Table 1 that they also had difficulty assigning Brefeld's figures to named genera or to indicate type of conidiogenesis present. Nevertheless, there seems no doubt that such an anamorphic state is produced in **Pseudopezicula tracheiphila.** The observations by Levadoux (**1944**) that the asexual spores seem to begin to germinate, but never form a germ tube raises the possibility that the anamorph may be spermatial. We also have seen no germination of these spores. On the other hand, Hennenger's (**1954**) detailed study of apothecial development has no mention of any anamorph, and no spermatial state was reported. The anamorphic state was assigned to **Botrytis** by Saccardo and Saccardo (**1906**), who named it **Botrytis tracheiphila**, and they should be credited with authorship of the name, since Müller-Thurgau did not apply any name to this anamorph. So far as we know, the only other author ever to take up this name was Rehm (**1912**), who cited it (incorrectly) as **B. tracheiphila** H. Müll. It cannot possibly represent a species of **Botrytis** by today's standards (FIG. 7 F), though possibly the Saccardos were influenced by the occasionally clustered spores and by the "sclerotia" which Müller-Thurgau described as developing in cultures grown on gelatine-solidified medium. Though this anamorph in some respects, but not in spore-shape, resembles a **Myrioconium** state (Schumacher and Kohn, **1985**: figs. 14-29), we transfer it here to **Phialophora**, with which it shares more features in common (Arx, **1981**).

A conidial (or spermatial) anamorph is formed by the American **Pseudopezicula tetraspora** only several weeks after ascospore germination, and is rare and easily overlooked (FIG. 8 F).. Ascospores germinate much as they do in the European species (Müller-Thurgau, **1903**, **1913**; Galet, **1977**), with an initial, normally lateral bulge which develops into a vesicle of the kind termed a "secondary spore" by Carpenter (**1976**), from which one or more germ tubes emerge (FIG. 4). Coiling hyphae soon form in both species. Eventually, in the American species, apothecia form on some agar media (malt agar, **Vitis**-stem extract medium), but not on other media (potato-dextrose agar). We believe the "sclerotia" illustrated by Müller-Thurgau (**1903**) for the European species to be incipient apothecia, and also to be the "pseudoapothecia" of Hahn (**1957**).

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Studies on Ectomycorrhizae II *

Introducing Remarks on Characterization and Identification

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This series describes anatomical and morphological studies on ectomycorrhizae. Keys to the characterized mycorrhizae will be provided. In later papers of this series, the keys will be enlarged by inclusion of newly described mycorrhizae.

SUMMARY
The literature dealing with characterization and identification of ectomycorrhizae is shortly summarized and discussed. The methods applied for characterization and identification in this series are described comprehensively.

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* AGERER, R. (1985) - Zur Ökologie der Mykorrhizapilze. Bibl. Myc. 97: 1 - 160 is considered as part I of the series.

KEY WORDS
ectomycorrhizae-characterization,
-identification, -anatomy, -morphology,
-surface view, -longitudinal section,
-cross section, inner surface of mantle,
chemical reaction, autofluorescence,
nucleus, siderophilous granulation,
emanating hyphae, rhizomorph.

I INTRODUCTION

In 1885 FRANK named those roots which are intimately associated with mycelia of fungi as mycorrhizae. Since that time many attempts to identify the fungi responsible for producing the mycorrhizae have been made. Some papers present verification of the mycorrhizal status of different fungi and some try to characterize the mycorrhizae on morphological and anatomical grounds. The first worker to identify a mycorrhiza as an organ of a known fungus was REESS (1880, 1885, 1885a, REESS & FISCH 1887). He described the connections between the fungal mantle of the mycorrhizae and the fruitbodies of Elaphomyces granulatus. In REESS & FISCH in 1887, REESS provided detailed drawings of this mycorrhiza with true fruitbody-mycorrhiza connections. This work leaves no reason to believe that the well known mycorrhiza formed by Cenococcum geophilum is identical with the mycorrhiza of Elaphomyces granulatus, which REESS had studied thoroughly. Mycorrhiza-fungus connections were also detected for Elaphomyces variegatus by LEWTON-BRIAN (1901), who stressed that there was no doubt that the characterized mycorrhizae were formed by this fungus. The same was shown recently for Elaphomyces muricatus by FONTANA & CENTRELLA (1967) and in synthesis experiments by MILLER & MILLER (1984).

It is possible that in the 19th century NOACK (1889) succeeded in identifying the mycorrhizae formed by Geastrum fimbriatum and G. fornicatum, but his figures are not very convincing, especially because NOACK indicated up to half a dozen different mycelia as hyphae of Geastrum. For the species Hygrophorus russula, Tricholoma terreum, Cortinarius callisteus, C. caerulescens, C. fulmineus and Lactarius piperatus NOACK claimed that he found the mycorrhizae via connection with fruitbodies, but illustrated neither these mycorrhizae nor their connections.

The associated organisms of many mycorrhizae have since been identified by detection of connections between formed fruitbodies and their hosts (Tab.1).

SCHRAMM (1966) compared the attached mycelia or rhizomorphs of mycorrhizae with those of neighbouring fruitbodies in black wastes of anthracite mining. He thus was able to identify the mycorrhizae. He looked for single trees with only a few mycorrhizae. The chance to get the true mycorrhiza for the fungus was increased by this method. However, comparison of rhizomorphs or hyphae of the stipe with those of the mycorrhizae in forests with many fungi and types of mycorrhizae is far more difficult.

Since the investigations by FUCHS (1911) and by MELIN (1922, 1923, 1923a, 1924, 1925) many syntheses of mycorrhizae using mycelia from known fruitbodies have been reported. In MELIN's (1923) opinion identification of mycorrhizae by discovering hyphal connections with fruitbodies is too uncertain because of the difficulties involved in following the hyphae between these structures. MELIN excavated many fruitbodies without success which is probably one of the reasons why he favoured the method of synthesizing the mycorrhizae. In many cases, however, it is almost impossible to culture obligate mycorrhizal fungi; this is true e.g. for most species of Russula.

Since the early twenties numerous attempts have been done to identify mycorrhizal fungi. Often only the fact that a fungus was mycorrhizal was registered, while only rarely were the synthesized mycorrhizae exactly characterized. Detailed descriptions of synthesized mycorrhizae are

TABLE 1

Fungus	Host	Author
Amphinema byssoides	Pinus strobus	FASSI & VECCHI (1962)
Arcangeliella asterosperma	Quercus pubescens	LUPPI & GAUTERO (1967)
Balsamea platyspora	Tilia tomentosa	CERUTI & BUSSETTI (1962)
Boletus edulis	Quercus robur	LUPPI & GAUTERO (1967)
speciosus	Quercus spec.	PENNINGTON (1908)
Byssocorticium atrovirens	Quercus petraea	LUPPI & GAUTERO (1967)
Byssoporia terrestris	Pseudotsuga menziesii	ZAK (1969)
Cantharellus floccosus	Abies firma	MASUI (1926)
	Pinus densiflora	MASUI (1927)
Cortinarius multiformis	Quercus petraea	LUPPI & GAUTERO (1967)
rubipes	Quercus spec.	KAUFFMAN (1906)
spec.	Alnus japonica	MASUI (1926 a)
	Pinus densiflora	MASUI (1927)
Dermocybe cinnamomea	Pinus densiflora	MASUI (1927)
	Populus tremula	MASUI (1927)
Elaphomyces granulatus	Pinus spec.	LEWTON-BRIAN (1901)
muricatus	Fagus silvatica	FONTANA & CENTRELLA (1967)
Endogone lactiflua	Pinus strobus	FASSI (1965)

Gasteromycetes spec.	Pinus kesiya	MISHRA & SHARMA (1981)
Genea klotzschii	Quercus petraea	FONTANA & CENTRELLA (1967)
	Carpinus betulus	FONTANA & CENTRELLA (1967)
Hebeloma crustuliniforme	Populus "euroamericana"	FONTANA (1961)
hiemale	Pinus strobus	FASSI & VECCHI (1962)
	Populus "euroamericana"	FONTANA (1963)
	Salix purpurea	FONTANA (1963)
mesophaeum	Pinus strobus	FASSI & FONTANA (1966)
Hydnum affine	Pinus densiflora	MASUI (1927)
Hymenogaster clathroides	Quercus petraea	FONTANA & CENTRELLA (1967)
tener	Quercus petraea	FONTANA & CENTRELLA (1967)
Hymenomycetes spec.	Pinus kesiya	MISHRA & SHARMA (1981)
Laccaria amethystina	Fagus silvatica	MEYER (1963)
laccata	Pinus strobus	FASSI & FONTANA (1966)
Lactarius chrysorrheus	Quercus petraea	LUPPI & GAUTERO (1967)
flexuosus	Quercus pubescens	LUPPI & GAUTERO (1967)
obscuratus	Alnus rubra	FROIDEVAUX (1973)
rufus	Picea sitchensis	ALEXANDER (1981)
vellereus	Quercus petraea	LUPPI & GAUTERO (1967)
Leccinum scabrum	Betula alba	McDOUGALL (1914)
Pisolithus tinctorius	Eucalyptus nova-anglica	ROSE et al. (1981)
"Polyporus leucomelas"	Pinus densiflora	MASUI (1927)
Rhizopogon rubescens	Pinus silvestris	FONTANA & CENTRELLA (1967)
Rhodopaxillus nudus	Populus monilifera	FONTANA (1961)
	Populus nigra	FONTANA (1961)

(Table 1 continued)

Russula emetica	Quercus spec.	PENNINGTON (1908)
grisea	Tilia tomentosa	CERUTI & BUSSETTI (1962)
spec.	Tilia americana	McDOUGALL (1914)
vesca	Quercus petraea	LUPPI & GAUTERO (1967)
violascens	Quercus petraea	LUPPI & GAUTERO (1967)
Scleroderma geaster	Eucalyptus nova-anglica	ROSE et al. (1981)
vulgare	Quercus alba	McDOUGALL (1914)
Suillus bovinus	Pinus densiflora	MASUI (1927)
	Pinus strobus	FASSI & VECCHI (1962)
luteus	Pinus strobus	FASSI & VECCHI (1962)
Tricholoma albobrunneum	Quercus petraea	LUPPI & GAUTERO (1967)
	Quercus pubescens	LUPPI & GAUTERO (1967)
caligatum	Pinus densiflora	MASUI (1927)
matsutake	Pinus densiflora	MASUI (1927)
transmutans	Quercus spec.	PENNINGTON (1908)
Thelephora terrestris	Pinus strobus	FASSI & FONTANA (1966)
Tuber albidum	Pinus strobus	SCANNERINI & PALENZONA (1967)
Xerocomus subtomentosus	Tilia tomentosa	CERUTI & BUSSETTI (1962)

provided by ALEXANDER (1981), ANTIBUS et al. (1981), FONTANA & PALENZONA (1969), HACSKAYLO & BRUCHET (1972), LAIHO (1970), LINNEMANN (1969, 1971), LUPPI & GAUTERO (1967), MARX & BRYAN (1969), MASUI (1927), MELIN (1922, 1923, 1923a, 1924), PALM & STEWART (1984), PACHLEWSKI & PACHLEWSKA (1965, 1974, 1974a), RIFFLE (1973), TRAPPE (1967), ZAK (1969, 1971), ZAK & LARSEN (1978).

A further method sometimes used to identify mycorrhizae [CERUTI & BUSSETTI (1962), CHU-CHOU & GRACE (1981, 1982, 1983, 1983a), PACHLEWSKI (1968), THOMAS & JACKSON (1979), ZAK & LARSEN (1978)] is involving the comparison of cultures obtained from mycorrhizal roots with cultures of known mycorrhizal fungi from the same plots. This method, however, may lead to errors because different fungi can have very similar characteristics when grown in pure cultures. On the other hand strain-specific differences of one and the same species may exist and thus falsely suggest different species.

Among the most important papers describing the characterization of more than one mycorrhiza by unknown fungi in nature, are those of CHILVERS (1968) for _Eucalyptus,_ FONTANA (1961) for _Populus,_ FONTANA (1962) for _Salix,_ FRANK (1885) for _Carpinus betulus_ and _Fagus silvatica,_ MASUI (1926b) for _Quercus pausidentata,_ MARKS (1965) for _Pinus radiata,_ MEJSTRIK (1971) for _Pinus radiata,_ NEAL et al. (1968) for _Alnus rubra,_ PACHLEWSKI (1952) for _Larix sudetica_ and _L. polonica,_ PACHLEWSKI (1955) for _Abies alba,_ PACHLEWSKI & GAGALSKA (1953) for _Quercus spec.,_ PACHLEWSKI & PACHLEWSKA (1965) for _Picea excelsa_ and _Carpinus betulus,_ RAMBELLI (1967, 1970) for _Pinus radiata_ and VOIRY (1981) for _Quercus petraea_ and _Fagus silvatica._

DOMINIK (1969) published a key for ectomycorrhizae, which is today often used to designate particular mycorrhiza types collected in the field. This is the most advanced key for mycorrhizal types up to now. DOMINIK distinguished several types of mycorrhizae, but unfortunately he established his key only on features seen in cross sections and on the colour of the mycorrhizae.

Both TRAPPE (1967a) and ZAK (1973) stressed that classification of ectomycorrhizae is urgently needed. Interpretation of the results of physiological research depends on having well known, unequivocally characterized organisms. This is the only way to get predictable and reproduceable results. The same is true for pathological research. In this connection researches on one of the more important problems of our day - the die-back of trees - depend on the reliable characterization of mycorrhizae. Such knowledge is also essential for ecological research and for studies on the application of mycorrhizae for wood production.

TRAPPE (1967a), ZAK (1973), and GODBOUT & FORTIN (1985) reviewed earlier attempts to characterize and classify ectomycorrhizae and deplored the deficit of exact descriptions and illustrations. ZAK himself began a series of such studies, the first of which appeared in 1969 (ZAK 1969). Other scientists described diverse mycorrhizae (see above) but up to now a key which will enable the exact recognition of mycorrhizae is lacking. For this reason we have commenced a series of analyses of mycorrhizae based upon the use of a diagnostic key. The present study characterizes the mycorrhizae formed by for fungi of the genera Lactarius and Russula.

II MATERIAL AND METHOD, AND USED CHARACTERISTICS

1. Method of identification and isolation of the mycorrhizae

Fruitbodies of known fungi were carefully excavated using a sharp knife to obtain a cor. This method ensures that roots and rootlets are retained in association with the base of the stipe. Before cutting the core the base of the stipe was cut to ensure that it had not moved. The soil with mycorrhizae and stipe base were then allowed to soak water, after which the soil debris was washed away cautiously and gradually, using the finest needles, forceps and paint-brushes. During the process of washing all parts of mycorrhizae and adhering soil debris were kept immersed so that the loosened particles could float away and so reveal the mycorrhizae and the connections to the stipe. If no connections were found a further core was examined. After exposing all mycorrhizae which were connected with the fruitbody plus adjacent ones of identical apperance, the mycorrhizae were excised, phoptographed, and stored for further investigation. One part of the sample was placed in a small flask with sterile water for investigation of fresh material, a second in the fixative AFE (Acetic Acid : Formaldehyde : Ethanol 70% = 5 : 5 : 90) for preparation of cross- and longitudial sections, and a third part of the sample was placed in AFE as a reference specimen. For sorting, the magnifications 12x and 25x were used (see below).

2. Reference specimens of fruitbodies and of mycorrhizae

For all mycorrhizae reference specimens were preserved. These have the same function as type specimens of plants and fungi. They are designated accurately. Additionally diapositives were made to complete the reference specimen. All specimens of mycorrhizae and fruitbodies were carefully and completely labelled and are stored in Herbarium R. Agerer (Herb. RA) in Munich.

For photography the following materials and apparatus was used.
Wild-Stereomikroskop M5 with apochromatic objective, standard magnification 6x, 12x, 25x, 50x, eye pieces 10x, with 2 halogen surface light lamps 6 V 20 W, with blue filters 16.5 (and 12.5) - Wild Photoautomat MPS 45 - Agfacolor 200CT as film material.

The real magnifications 2.4 x, 4.8 x, 10 x and 20 x (on the diapositive) were used.

3. Colour of mycorrhizae

Colour was characterized with the above mentioned apparatus by using a blue filter. A colour-chart would have been useful but was not included in the present studies, because the described mycorrhizae will be shown by colour plates in the "Atlas of Ectomycorrhizae" (Einhorn-Verlag, Schwäbisch Gmünd, Germany).

For the descriptions, the colour of the tip of mycorrhizae, and of the neighbouring and older parts was characterized.

4. Size of mycorrhizae

The gross morphology is characterized by measurement of the diametre and length of the last unramified mycorrhizal tip. The length of the whole mycorrhizal system varies and is of no diagnostic value. The type of ramification is expressed by drawings and in terms of form viz: pyramidal, dichotomous or others.

5. Colour reaction in UV of whole mycorrhiza

These researches were done with fresh material, stored for only a short time in sterile tap water. We used a FLUOTEST handlamp Heraeus T 5301, with the wavelength 254 nm and 366 nm.

6. Colour reactions of mycorrhizae

The reactions of fresh mycorrhizae to a range of chemical reagents were studied. A small piece of mycorrhiza was taken with forceps and placed in a drop of water under the dissecting microscope. A part of the fungal mantle was then teased off with a fine needle. The water was drawn off with a piece of filter paper and the reagent was then placed on the mantle, which was covered with a cover glass and examined with the microscope to observe if colour changes occur. The surplus reagent was washed away with water, and the remaining colour changes were recorded.

The following chemicals were applied: Acetic-Fuchsin (GERLACH 1969, part of "Pianese" dye) - a-Naphtol (MEIXNER 1975) - Ammonium-Hydroxide (MEIXNER 1975) - Brillant-Kresyl-Blue (MATHEIS 1975) - Chlorazol Black E (MATHEIS 1975) - Cotton-Blue (ERB & MATHEIS 1983) - Erythrosin (MATHEIS 1975) - Fast-Green (GERLACH 1969, part of "Johansen" dye) - Gujak (ERB & MATHEIS 1983) - Iron-sulfate (MEIXNER 1975) - KOH 15 % - Kongo-Red (ERB & MATHEIS 1983) - Magnesium-Acetate (cr. 0,5 g in 20 ml Aqua purif.) - Malachit-Green (GERLACH 1969, part of "Pianese" dye) - Martius-Yellow (GERLACH 1969, part of "Pianese" dye) - Melzer's Reagent

(MOSER 1978) - Phenol (MEIXNER 1975) - Phenol-Anilin (MEIXNER 1975) - Phloxin B (MATHEIS 1975) - Stahl's EP-Reagent (STAHL 1953) - Sulfo-Vanillin (ERB & MATHEIS 1983) - Toluidin-Blue (MATHEIS 1975).

The colour reactions were mostly studied with mycorrhizae that had been stored in the fresh condition for 1 - 5 months in a refrigerator at + 4 C. Additional chemicals to a first set of reagents should be used and so some reagents were tested only after 5 months. Some reactions may have been lost as a result of the long storage time (ZAK 1973), but it seems unlikely that new reactions will have appeared.

Colour changes were always observed under identical conditions of light-quality and magnification viz: - halogen-light without blue-filter, identical voltage, magnification 800x.

7. Mantle of the mycorrhizae (surface views)

In order to characterize the surface views of the mycorrhizae, small pieces of mantle were peeled off with fine forceps and needles. Some mantle pieces were oriented with outer surface uppermost and others with the inner surface focussing upwards. If the slide is held obliquely the convex outside of the mycorrhiza can be easily seen, so one can be certain of the orientation of the mantle. For photography and line drawings, the highest magnification (1000x) was used in order to reduce the depth of field. So that only the outermost or the innermost cells, respectively, of the mantle were in focus and photographed or drawn.

8. Emanating hyphae and rhizomorphs

The emanating hyphae were studied in tangential section or on mantle pieces prepared as described above.

Tangential sections were made by hand, under a dissecting microscope with fine forceps and a thin razor blade, which had been obliquely broken. Razor blades which are not brittle are unsuitable, because the broken edge is easily bent.

The rhizomorphs were prepared as whole structures only, being sometimes squashed if necessary. If very thick rhizomorphs were studied longitudinal or cross-sections were made.

9. Autofluorescence of mantle and adhering hyphae in UV and BLUE light by microscopy

The autofluorescence was studied with the aid of Leitz LABORLUX D with Epi-fluorescence. Filters used were 340 - 380 nm (UV) and 450 - 490 nm (BLUE), and the medium Lactic-acid and water.

10. Staining of nuclei

Nuclei were stained by two methods.

a. With fluorochromes: Bisbenzimide (Serva, mixture of 0,1% Triton in 0,02% Bisbenzimide) and DAPI (Sigma, mixture of 0,01% DAPI in 0,1% Triton).

The mantle of a mycorrhiza fixed in AFE was peeled off, the remaining fixative was blotted off. A drop of reagent was added, covered with a cover-glass and then the remaining reagent was washed away by repeated adding of 0,1% Triton until the hyphae were sufficiently discoloured to demonstrate the nuclei.

b. With aceto-carmine (after the method provided by CLEMENCON 1978; 3 - 5 mm long parts of mycorrhizae were used, after staining (CLEMENCON 1978) hyphae and mantle fragments had been teased off, placed in a drop of Hoyer-solution, and examined by microscopy) if the hyphae showed a too strong autofluorescence.

c. With aceto-carmine it was also possible to display the siderophilous reaction of the hyphae of mantles (CLEMENCON 1978).

11. Cross- and longitudinal sections

The sections were made with a LEITZ Kryotome 1321.

Sections were prepared as follows: mycorrhizae fixed in AFE were cut in ca. 5 mm long pieces and immersed in a solution of 2 - 5 % glycerine/water. The oriented mycorrhizae were cut in 2 - 6 um thick sections.

If the sections were to be examined in cotton blue (ERB & MATHEIS 1983) then they were placed into a drop of this reagent, oriented by a pair of needles, and finally covered with a cover-glass.

If the sections were to be tinged by several reagents in continuous steps, then the sections were glued to the slide with glycerine gelatine. For that purpose a small piece of glycerine gelatine was placed on the slide and spread evenly. The sections then were put into a drop of destilled water, oriented and dried.
Sections prepared in this way were dyed by the method according to Delafield (GERLACH 1969).

12. Drawings and photographs

If the cells to be drawn lay in more or less a single plane drawings were made with the aid of a camera lucida. The original magnification of the drawings was 3000x and these were photographically reduced.
If the hyphae were not approximately in one plane, then the drawings were made by measuring the subjects which were then delineated on a paper lying above a grid with lines on distances of 15 mm. All pencil line drawings are copied on transparent paper with Indian ink. The thickness of the individual lines approximates to scale the thickness of the cell walls. Very thick walls are designated by two lines (= outer and inner border of the wall); in this case the distance between the two lines marks the thickness of the cell wall.

Microscopy and photography was made with a LEITZ DIALUX 22 and a VARIOORTHOMAT. The objective used for photography was mostly the 63x in connection with an optovar 2x. Film was Agfapan F and Agfaortho 25.

The dimensions of cells in surface view of pseudoparenchymatous mycorrhizae (*Russula ochroleuca*) were measured by the following procedure. A paper, in which 20 x 20 µm square (to scale) was cut was laid down on the original drawings of the surface structure. Then up to 15 different positions were chosen and the number of complete plus cut cells was registered. The average value of these numbers was used to characterize the dimensions of the cells.

III Acknowledgements

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REVUE DES LIVRES

par

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Belgique.

WOOD PRESERVATION IN ITALY, by A. GAMBETTA, E. ORLANDI and R. COCKCROFT, information n° 505, 48 p., 12 pl., tabs., 1985. Swedish National Board for Technical Development, Box 23200, S-100 72 Stockholm, Sweden.

Another fascicle of the series which describes and illustrates the fungus hazards on timbers in Italy and the timber preservative and curative treatments applied. Italian regulations and Italian standards in wood preservatives are commented. A list of organizations concerned with wood deterioration and its protection is provided.

OUTLINE OF THE ASCOMYCETES - 4, by Ove ERIKSSON and D.L. HAWKSWORTH, 79 p., 16 x 24 cm, paperback, 1985. Ove Eriksson ed., Institute of Ecological Botany, University of Umea, S-901 87 Umea, Sweden.

In this fourth part of the Systema Ascomycetum, Ove Eriksson, with D. Hawksworth, proposes a revised system in which lichen-forming genera are integrated. The present system recognizes 209 families (with 154 synonyms) disposed in 43 orders and a group of 26 families of uncertain affinity. Each family is outlined by a list of the pertaining genera. That revised system is based on most recent publications and on written comments from authorities in the field. Further comments about this edition are welcome in view of a 1986 edition of the Outline.

ARCTIC AND ALPINE FUNGI - 1, by G. GULDEN, K.M. JENSSEN and J. STORDAL, 62 p., ill., 25 col. phot., 17 x 24 cm, 1985. Soppkonsulenten, Wesselsgt. 3, 0165 Oslo 1, Norway. Price : NOK 125.- plus postage.

This fascicle composed of loose sheets is the first of a series which projects the descripiton and illustration of arctic and alpine Basidiomycetes as an updating of the pioneers J. Favre (1955) and F.H. Moller's (1945) classics.
The first fascicle provides colour photographs (in situ), microscopic drawings and descriptions of 25 species from mountain areas in South Norway. An introduction informs on the relative abundance and number of species of the represented genera in arctic-alpine area, with reference to the literature. The project is to extend to other arctic-alpine genera and to provide an index to all records of arctic and alpine

mushrooms. The photographs are of excellent quality. The descriptions are acurate, accompagnied by taxonomic comments and ecological notes.

I FUNGHI SECCHI, NELLA PRATICA ISPETTIVA, by N. TOGNI, 59 p., ill,. col. phot., with a loose colour chart, 16 x 21 cm, paperback, 1985. Publ. Camera di Comercio, Servizio Igiene Pubblica, U.S.L. n.16, Via Canaletto 15, 41 1000 Modena, Italia.

This booklet is dedicated to the control of dried mushrooms. Indeed, it is of importance in countries where dry edible mushrooms of any kinds are current on the market, that such products are checked for proper identification, technical condition and sanitary quality. Fifteen species are described and illustrated in commercial dry state, macroscopically and microscopically. Dried mushrooms (Bolete) are illustrated in four different quality categories depending on the time and the way of drying but also in four states of alterations that must be rejected. A useful guide to mushroom dealers, control officers and customers.

ZUR KENNTNIS DER PILZE IN DEN NORDLICHEN KALKALPEN, by H. SCHMID-HECKEL, Nationalpark Brechtesgaden Forschungsberichte 8, 201 p., 104 figs., 7 col. pl. 21 x 30 cm, paperback, 1985. Bayerischen Staatsministeriums für Landesentwicklung und Umweltfragen. Regensburg, Germany.

The geographical area described by the author is an Alpine national reserve between 600 and 2000 m in South Bavaria. It is characterized by seven types of vegetation. Amongst them, those typified by *Picea, Fagus, Larix, Rhododendrum, Salix, Alnus, Betula*. The mycosociology of 210 species of higher fungi is analysed. In another part the almost 1450 collected fungi are described taxonomically, the specimens are listed, comments on their distribution and ecology are given. Many are properly illustrated. A serious contribution to the Alpine mycoflora in Europe.

TAXONOMY OF THE DACTYLARIA COMPLEX, IV-VI, by G.S. DE HOOG and C. A.N. VAN OORSCHOT, CBS Studies in Mycology n° 26, 124 p., 69 figs., 16 x 24 cm, 1985. Centraalbureau voor Schimmelcultures, P.O. Box 273, 3740 AG Baarn, The Netherlands.

In a first part (IV) De Hoog revises the genus *Dactylaria* Saccardo and subdivides it into four sections : *Dactylaria, Diplorhinotrichum, Mirandina* and *Pleurophragmium*. Fourty-one species are accepted. The genus *Neta* Shearer and Crane is included with six species. Keys to species of *Subulispora* (*Solosympodiella*) and *Scolecobasidium* versus *Ochroconis* are provided with description of two new species. In a second part (V) Van Oorschot distinguishes the affine genera *Dactylella, Arthrobotrys, Geniculifera* and *Duddingtonia* with alltogether 38 accepted species. In the third part (VI) both authors propose a general key to the related sympodulate anamorphic genera and a revised list of epithets in *Dactylaria* and *Arthrobotrys* complexes.

A MONOGRAPH OF STILBELLA AND SOME ALLIED HYPHOMYCETES, by K.A. SEIFERT, CBS Studies in Mycology n° 27, 235 p., 61 figs., 16 x 24 cm, 1985. Centraalbureau voor Schimmelcultures, P.O. Box 273, 3740 AG Baarn, The Netherlands.

The anamorph genera *Stilbella* and *Stilbum* are revised, with emphasis on classification of related teleomorphs. Five genera are fully monographed: *Stilbella* (19 species), *Didymostilbe* (5 species), *Rhizostilbella* (1 species), *Polycephalomyces* (4 species) and *Dendrostilbella* (3 species). Some species are also revised in *Tubercularia* (6) and *Gliocladium* (5). The structure of the synnema, the conidiophore branching, the pigment change in KOH are investigated and used in the taxonomy of the anamorphs. The revised genera have ontogenic connections with Hypocreales, but *Dendrostilbella* with *Claussenomyces* in the Helotiales. *Polycephalomyces* have no known teleomorph. 204 anamorphic names are revised as doubtful or are reclassified.

A REDISPOSITION OF THE SPECIES REFERRED TO THE ASCOMYCETES GENUS MICROTHELIA, by D.L. HAWKSWORTH, Bulletin of the British Museum, Botany Series vol. 14(2), 138 p., 73 figs., paperback, 1985. British Museum Publ. Cromwell Road, London SW7 5BD, England. Price: £ 24.-

The eventually lichen-forming genus *Microthelia* Körber, the name of which is not available, is revised in the classification scheme of the bitunicate Pyrenomycetes with one-septate brown ascospores. Besides the already segregated genera,*Kirschsteiniothelia, Astrosphaeriella* and *Lichenothelia* and *Jahnula,* 18 new combinations and 2 new species in the group are disposed in the genus *Mycomicrothelia* Keissler, including so 26 species, many of which are tropical. A new genus, *Peridiothelia*, includes three non-lichenized European species, with 3 new combinations. 144 other taxa assigned to *Microthelia* are revised and redisposed. The author emphasizes the anatomical structure of the ascoma, its shape and its position on the host in the distinction of the genera. All descriptions are illustrated by macro and microphotographs of the ascoma, ascoma cross-sections and ascospores and by ascospores outline drawings.

BIOLOGICAL CONTROL ON THE PHYLLOPLANE, by C.E. WINDELS and S. LINDOW, ed., Symposium Book n° 3, vi + 170 p., figs., 21 x 14 cm, paperback, 1985. The American Phytopathological Society, 3340 Pilot Knob Road, St Paul, Minnesota 55121, U.S.A. Price: US $ 18.- APS members; $ 24.- nonmembers.

It is a stimulating record of a Symposium held by specialists committees of the American and Canadian Phytopathological Societies in Guelph in August 1984, on leaf disease biological control. Progress in exploring, understanding and manipulating the microbial community on the leaf surface to control foliar plant pathogens was the target. Much has been done for 20 years when trials on the antagonism of bacterial to fungal leaf pathogens first developed. In parallel of and based on investigations on the very complex microbial coenose on the phylloplane and on its chemical, physical and environmental factors, strategies of selecting the antagonistic organisms with desirable attributes and particular nutritional pattern and antibiocidal activity are being explored and defined.

As well investigations on genetic manipulations of potential antagonists are developing. Bacterial and fungal diseases are susceptible to biocontrol but also frost injury can be avoided by ice nucleation by bacteria. The matter of phylloplane biology and biocontrol appears to be extremely complex. This symposium raises challenges for the future and will enhance more intensive ecological research on both aerial and subterranean plant parts and microflora.

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REVISED INSTRUCTIONS TO AUTHORS FOR PREPARING CAMERA-READY MANUSCRIPTS FOR MYCOTAXON

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THE revolution in methodology for preparing manuscript copy that has occurred in the last decade dictates this revision of instructions to authors.

There are **six steps** which you should follow when you have completed your research if you wish to publish in MYCOTAXON. We urge you to read and re-read these instructions until you understand them fully.

Authors writing for MYCOTAXON are given complete freedom in certain matters. We feel that most often an author knows best how to present the material, and we do not wish to impose any of the usual editorial strictures on authors. Internal consistency within each article is far more important than consistency among different articles appearing in the journal. We do *require* that the manuscript be typed so that it will fit a specific page size, that the text be single-spaced, and with a certain arrangement in the typing of the title, author's name, and author's address (see below, Step 4, §1, §4, §6). Otherwise we have only certain *recommendations,* as follows:

Title. A title should be as brief as is consistent with conveying enough information to someone reading the table of contents that he or she will be able to judge accurately the scope and content of the paper. Avoid the use of abbreviations in titles, do not use either italics or underlining in titles, and avoid any author citations of taxa in titles.

References. You may cite references however you wish, by author/date, by number, or by footnote. Journal names may be spelled out in full or abbreviated, but be consistent. We recommend that you use one of the conventional systems; that provided in *B-P-H* (*Botanico-Periodico-Huntianum,* published by Hunt Botanical Library, Pittsburgh, Pennsylvania) is particularly good, as is that of the *World List of Scientific Periodicals* (published by Butterworth & Co., London). The most detailed information on book titles, editions, and exact dates of publication is often found in Stafleu

& Cowan's *Taxonomic Literature, ed. 2,* (published by Bohn, Scheltema & Holkema, Utrecht).

Scientific names. Only the names of genera and infrageneric taxa, and the names of species and infraspecific epithets, should be *italicized;* other scientific names should be in Roman typeface. On typewriters in which italic typeface is not available, such names may be underlined or given in bold face instead. Do not use underlining for any other purpose.

Latin diagnoses. We request that you have your Latin diagnoses checked by a competent botanical Latin scholar.

Code of Nomenclature. Authors are urged to conform to the provisions of the International Code of Botanical Nomenclature.

Summaries. Short papers, 4 or fewer pages in length, probably do not require a summary or abstract. For longer papers, a summary is useful, and recommended. We suggest that it be placed first, before the text. The summary may be in the language of the original article, or in another or additional languages. We will accept up to three such summaries, *e.g.,* an article in English with English, Russian, and Czech summaries would be wholly appropriate.

STEP 1. DETERMINE WHETHER YOUR WORK IS SUITABLE FOR MYCOTAXON

MYCOTAXON is specifically restricted to papers on the taxonomy and nomenclature of fungi and lichens. We intend this broadly, to include not only monographic work or arguments dealing with specific nomenclatural problems: we will also accept papers devoted to floristics, reviews of taxonomic groups or of taxonomic criteria, nomenclatural and taxonomic argumentation and polemics, proceedings of symposia on taxonomic or nomenclatural matters, subject, title, or taxon indices of taxonomists' writings, etc. Papers that deal with ecology, cytology, physiology, pathology, ultrastructure, etc., unless their *primary* focus is taxonomic, should be submitted to some other journal.

When authors are in doubt as to the suitability of their paper for MYCOTAXON, they are urged to send a draft copy of their manuscrtipt to the appropriate Co-Editor for a decision as to whether the content would be acceptable for the journal. The audience you hope to reach should be taxonomists and nomenclaturalists for this to be your journal of choice.

Articles may be of any length. A maximum of 64 free pages per author (based on senior authors) is permitted in any one volume. Partial costs of publication will be charged beyond 64 pages for each excess page (at 1986 printing costs, this charge is $15 per page).

STEP 2. PREPARE A DRAFT MANUSCRIPT AND OBTAIN PRE-SUBMISSION REVIEW

NO articles will be accepted for publication in MYCOTAXON that have not been given critical review by a specialist in some other institution than that of the author(s). Unlike other journals, where the editors send a manuscript to reviewers *after* it has been submitted, MYCOTAXON insists that the author must first submit a completed draft (*not* camera-ready copy) of the manuscript, including copies of the plates, for *critical* comment to at least one scientist capable of judging the quality and presentation of the research results. This must be done *before* the author has had his final manuscript typed for submission to MYCOTAXON. For papers 20 or more pages in length, *two* such pre-submission reviewers are required. Usually an author knows best who is most competent in the author's field to do such critical reviews. Most authors name their pre-submission reviewers in their acknowledgements. In those cases where an author is not certain whom to approach, a draft copy of the manuscript (or a detailed abstract) should be sent to the appropriate Co-Editor, who will then suggest several possible reviewers.

The comments of pre-submission reviewers should be carefully considered and the manuscript then altered to reflect these criticisms when they are judged to be constructive. Authers must submit the names and addresses of outside reviewers to the Editors at the time the final manuscript is submitted, with the understanding that the Editors may contact such reviewers if they have questions concerning the content of the paper. Alternatively, copies of the pre-submission reviewer's comments may accompany the manuscript when submitted. At the close of each volume, the names of all those who have provided pre-submission reviews will be separately acknowledged by the Editors in the journal.

STEP 3. PREPARE YOUR PLATES OF LINE DRAWINGS AND OF PHOTOGRAPHS FOR THE CAMERA-READY COPY BEFORE PREPARING FINAL TYPED COPY

PHOTOGRAPHS reproduce excellently with modern photo-offset lithography, and the method used is the production of a *halftone screen* by the printer. Gradations from white through grey to black are broken up into a series of dots of various sizes, just as is done with halftone plates printed by conventional letterpress methods. The same process is necessary for toned ink-wash or shaded pencil drawings. The screen used in MYCOTAXON is a 150-line screen, which will reproduce excellent detail (but perhaps not the extremely fine detail needed to please workers publishing transmission electron micrographs, where a finer screen and glossy paper is needed).

Because halftone screens are an added expense, authors are allowed one halftone plate (up to page size) for each ten pages of manuscript, or fraction thereof. (An 11-page manuscript thus qualifies for two halftone plates.) Authors who wish to publish papers with halftones in excess of this allowance must be prepared to pay for the extra cost of these (at 1986 prices, $15.00 for each such halftone screen). There are no extra costs for line drawings, so these may be used in any quantity. MYCOTAXON cannot publish colored plates, which are very expensive, unless authors are prepared to pay the full cost of these and are prepared to have acceptance of their paper delayed while such color plates are prepared.

The contrast among photographs grouped to make up one plate should not be too great. Plates should be planned to utilize the maximum page width whenever possible. Individual photographs making up a plate should be trimmed *squarely* on a good paper cutter so that the edges of adjacent photographs fit together neatly without any spaces between photographs. Commercially available press-on line stripping can be applied between photographs, if desired. Immense care is essential, and the individual photographs should be mounted and grouped together on stiff paperboard, either with rubber cement or with photographic mounting tissue. Of course you should always use *glossy* prints for your plates. *Never* put your typed legend on the same sheet intended for halftone reproduction, since two separate processes are involved, (i) halftone screening for photographs, and (ii) normal photography for typescript and line drawings.

Line drawings should normally be made with black India ink. Individual line drawings can be cut out and assembled on a white background to make an attractive plate by glueing them to firm paperboard. The edges of these cut-outs will not reproduce if carefully glued, and need not be cut squarely. Plates of line drawings should also be planned to utilize full page width when possible. Do *not* mix photographs and line drawings in the same plate!

A WORD OF WARNING ON AMOUNT OF REDUCTION

Authors are cautioned against reducing their plates too much. Photographs reduced to less than 2/3 of their original size often suffer in reproduction. Line drawings should only very rarely be reduced to less than 1/2 of their original size. Leaving enough space *between* lines and dots is often more important than the width of the line or the diameter of the dot when line drawings are excessively reduced. Note also that lines which are drawn too fine sometimes disappear entirely in reduction.

DETERMINING THE SIZE OF YOUR PLATE

Whether a plate is composed of photographs or of line drawings, an author will wish to determine the dimensions of the figures as they will be finally printed in order to determine printed magnifications. If a figure does not occupy a full page, the author will also wish to determine the amount of space to leave blank on the final, camera-ready manuscript page. The text of your article must be typed within a specific size rectangle (as indicated under Step 4, §1). If you are using a Pica ("12 point") or an Elite ("10 point") typeface on your typewriter, these rectangles would be 20 x 12.5 cm for Elite, and 24 x 15 cm for Pica. The actual space that can be occupied by typed text or by a plate is, in the final printed version, 17.6 x 11 cm (see FIG. 1). There are five general options open to you which are outlined below.

(1) USING THE SAME REDUCTION AS THE TYPED TEXT

Surely the *easiest* plan for you and your typist is to allow your plate to receive the same reduction as the text. This means that you would plan your plate to be 12.5 cm wide if your text is in Elite size, and your plate could be any height not exceeding 20 cm: your figure would then reproduce at 88% of the submitted size. Using a Pica typewriter, you would plan your plate 15 cm wide, and any height not exceeding 24 cm, and your figure would reproduce at 73% of submitted size. In both cases the final width of the plate as printed will be 11 cm. You are recommended to insert your line drawings on the text pages in the exact position you want them when using this plan. Do *not* do this with photographic plates, however, but instead leave the exact amount of blank space necessary on that page of your typed manuscript. Submit your photographic plate, mounted on stiff paperboard, separately, since the printer must make a halftone screen from your photographs before they can be printed.

(2) USING NO REDUCTION

If you desire to reproduce your figures at the exact size they are drawn or photographed, you should plan your plate to be 11 cm wide, and not in excess of 17.6 cm in height.

(3) *OTHER REDUCTION POSSIBILITIES*

The relationship of final printed area, the area occupied by a figure on Elite or Pica manuscript paper, and any original figure size can be determined by consulting FIG. 1. The mathematics involved in computing the final magnifications is relatively simple.

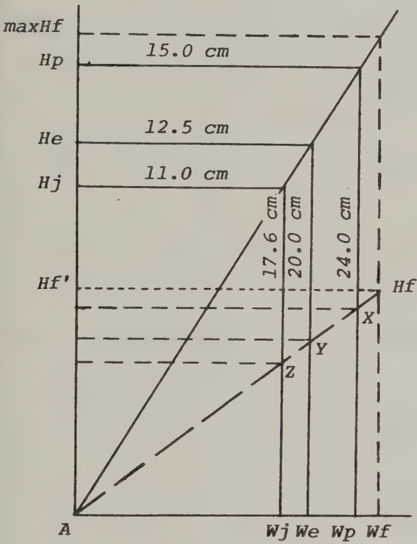

FIG. 1. *THE DIAGONAL METHOD OF PLATE PREPARATION.* Solid rectangles are established dimensions of *copy areas* for MYCOTAXON. A—Wj = *journal width* of printed copy = 11 cm. A—Hj = *journal height* of printed copy = 17.6 cm. A—We = permitted *Elite-typing width* = 12.5 cm. A—He = permitted *Elite-typing height* = 20 cm. A—Wp = permitted *Pica-typing width* = 15 cm. A—Hp = permitted *Pica-typing height* = 24 cm. A—Wf = actual *figure width.* A—maxHf = *maximum permitted figure height of a figure* A—Wf wide = 1.6 x A—Wf. A—Hf' = Wf—Hf = observed *height of figure* A—Wf wide. Wp—X = derived (measurable) *height* to be kept blank on a *Pica-typed manuscript* to allow insertion by the printer of a figure A—Wf—Hf—Hf'. We—Y = derived (measurable) *height* to be kept blank on an *Elite-typed manuscript* for the same purpose. Wj—Z = *printed height* of such a figure.

(4) *ILLUSTRATIONS LESS THAN FULL PAGE IN WIDTH*

While we do not normally recommend using less than full page width for illustrations, exceptions do exist where a small figure does not lend itself to the general rule. Any figure can be computed for reduction and fitted to the MYCOTAXON manuscript page by using the examples above and by consulting FIG. 1.

(5) *FIGURES SET LENGTHWISE ON THE PAGE*

Occasionally a figure does not lend itself to a printed width of 11 cm, whereas it would adapt to being printed lengthwise on the page, where 17.6 cm is available as the "width." There is no objection to this. The legend is then typed the full length of the rectangle, rather than the width, if there is room for the legend on the same page.

LETTERING AND NUMBERING YOUR PLATES

Avoid hand-lettering, which almost always looks crude. A good lettering device and India ink will suffice, but we recommend the use of press-on (or transfer) letters now available from many commercial concerns in a wide variety of typefaces and sizes. These should be in black, or, for use on dark portions of photographs, in white. A special sheet of transfer letters and symbols of particular convenience for biologists is called BIOPLATE. This contains a large proportion of the most commonly used letters and numbers for plates (in several sizes), various symbols useful in making graphs and maps, arrows, and even Greek letters that are seldom seen on normal transfer sheets. They are manufactured for us by a leading American firm, Prestype, Inc., and are available through the Managing Editor (see the back cover of the most recent issue of MYCOTAXON for the current prices).

Step 4. TYPING THE CAMERA-READY FINAL COPY

YOUR typist is the key to how attractive your manuscript will be. See that your typist has a copy of these instructions at hand, and that he or she knows exactly what is required. All typing is ideally done with a *carbon ribbon* to ensure good photographic reproduction with photo-offset lithography. The use of a fabric ribbon can result in such poor reproduction that an Editor will be forced to reject a manuscript. Best results are obtained with an electric typewriter. Hand-operated machines may be used if the typist has an even typing touch. Since many manuscripts are now prepared on word-processors and other computers, authors and typists should be aware that unless a dot-matrix printer is capable of producing "near letter-quality" printing, such printers should be avoided, and a letter-quality printer should be substituted (again preferably with a carbon ribbon).

Before beginning, the typist should consult the author concerning the position on the page to be occupied by any illustration and its legend. Careful placement of the figures will result in an attractive paper. When many figures occur, consider also the placement of figures on the facing page, and how their placement will balance with the figures on the page with which you are now working. While figures are normally inserted on the same page or the next following their first mention in the text, aesthetics may dictate otherwise.

Since *footnotes* appear at the bottom of pages, and *legends* to figures either at the bottom of the figure or on the facing page, the typist will need to type out the full footnote or legend ahead of time in order to allow sufficient space in the text for these to appear where they belong.

Typists must know that your figures, their placement in the manuscript, and their legends will dictate how the final text is to be typed.

It is a major error to put off decisions on figures until after the manuscript is typed, as this almost invariably causes later grief.

Discuss with your typist space-saving techniques. Be sure that the typist understands that typing should go all the way to the four margins of the rectangle. No space at the edges, or top or bottom, is needed. Discuss the possibilities outlined under Step 4, §8, which may result in saving space.

§1. All manuscript submitted to MYCOTAXON must be prepared so that the typed area is wholly within a rectangle, the dimensions of which are determined by the size of the typeface of the typewriter or word-processor. The great majority of typewriters are either Pica size (12 points, in printer's terminology), or the smaller Elite size (10 points). If the body of your paper is to be typed with a Pica-size typeface, the rectangle within which all lettering must be kept is 24 x 15 cm. If it is an Elite-size typeface, the rectangle is 20 x 12.5 cm. A very few typewriters have a typeface larger than 12 points; for these, use the Pica-size rectangle. With many word-processing machines, typeface will be smaller than 10 point, and a non-reduction rectangle 17.6 x 11 cm may be more appropriate. As a convenience to prospective authors, we have prepared *special manuscript paper* with these three rectangles ruled in light blue ink (which will not photograph). These may be obtained from the Managing Editor in pads of 50 sheets at our cost (consult the back cover of the most recent issue of MYCOTAXON for the current price). While this manuscript paper is not necessary, it can be a great convenience to your typist; or you can rule your own rectangle on typing paper, using a *very light blue pencil* only.

§2. *Clean* the typing faces of your typewriter thoroughly before beginning to type. A dirty typeface yields poor results, and exactly what you type will be reproduced.

§3. *Don't erase* when preparing final copy, since erasures often show when the copy is photographed. Also do not strike over a letter a second time, since this results in a blacker than usual letter which clearly shows up in the printed copy. It is best to paint over any errors with typewriter correction fluid, and then retype the word or line a second time. Or retype the correction on a separate piece of paper or a gummed correction strip and glue it carefully onto the manuscript to cover the incorrectly typed words(s).

§4. All articles in MYCOTAXON will be provided by the Managing Editor with a journal identification at the head of the first page, like the one on the first page of these Instructions. It is imperative that the typist leave sufficient blank space at the top of the title-page rectangle for this purpose. For Pica typefaces, leave 2.4 cm blank; for Elite typefaces leave 2.0 cm blank; for No-Reduction typefaces leave 1.8 cm blank. (The manuscript paper we have prepared and mentioned above [§1] has title guide marks.) The typist should center the title the appropriate distance down the title page of the manuscript, all in CAPITAL LETTERS. Use neither underlining nor italics in the title. Leave the next 1, 1-1/2, or 2 lines blank. The name(s) of the author(s) should be centered in CAPITAL LETTERS, on the next line, followed by one blank line. Then the author's address(es) should appear, either in upper and lower case *italics* or in upper and lower case Roman letters. Leave 1-1/2 or 2 blank lines before beginning the summary or other text matter. An abstract or summary placed ahead of the text may be typed narrower and preferably with a smaller typeface than the main text, if desired (see also §8, below).

§5. The first (title) page of *all* articles will always be an odd-numbered, *right-hand page*. Keep this in mind when planning the insertion of illustrations, particularly when the illustration is so large that its legend must appear on a facing page. An illustration appearing on manuscript page 3 requires its legend either on the same page or on manuscript page 2, its *facing page,* not on manuscript page 4 (which will always print on the back of manuscript page 3).

§6. The body of the text *must* be typed single-spaced. It is permissible, and preferable, to use 1-1/2 or 2 spaces between paragraphs to help set them off. *Never,* however, leave a blank line between references in literature cited, as this merely wastes space.

§7. In the upper portion of each sheet of your manuscript place the name of the senior author and the manuscript page number. Keep this as far away from the text as possible (leave at least 4 blank lines). The *final* page numbers will be inserted by the Managing Editor above your typed rectangle.

If it is necessary for an author to refer in the text to another part of the same paper by the use of a page number, substitute **XXX** for the page number so that the Managing Editor can insert the page reference (which may be up to three numbers) after he has assigned final pagination. An obvious difficulty is that he may not be able to match exactly the same type style you have used. You will also need to alert him at the time the manuscript is submitted, *e.g.,* "Page number must be inserted on MS pg. 10, line 14, referring back to MS pg. 6," so that he will be certain to insert the correct final page numbers at that point.

§8. You are certainly not restricted to the use of only one size of typeface in your article. Indeed, a larger typeface is most useful for the title, and for some headings. You can, for example, type the main text of your article on a Pica rectangle, using Pica typeface, but switch to the use of the smaller Elite typeface for the summary, Latin diagnoses, references cited, etc. To save space in long, monographic treatments, indices, etc., where the paper is likely to be used as a reference source rather than as a document to be read from beginning to end, you may wish to consider using an Elite typeface on a Pica rectangle throughout, which will appreciably reduce the number of final pages and save on offprint or reprint costs accordingly, and may reduce or eliminate excess page charges.

§9. The great majority of typewriters have each letter of equal width, whereas in conventional typesetting the letter "i" for example is much narrower than the letter "M." Some typewriters, many "smart" typewriters, and most word-processors have typefaces with *proportional* spacing, with letters of several widths so that the final product looks much more like conventional printing than does the usual typewritten copy. You may use either; proportional spacing is a luxury not available to all of us. Similarly typical typesetting produces "justified" copy, where both right and left margins are uniform (as in this article), another feature commonly available in word-processing equipment. Typing typically produces a ragged right margin, but we currently see a ragged right margin intentionally used in many books and publications produced by conventional typesetting. Use your own judgement as to which looks better to your eye.

§10. Some typewriters and most word-processors allow you to type with different typefaces on the same machine. A typical example of these typewriters is the IBM "Selectric" typewriter, in which the typing element is a removable ball that can be interchanged with others having a different type style or size of type. (IBM "Selectric" typefaces marked "10 pitch" are Pica size; those marked "12 pitch" are Elite size. Don't confuse "pitch" with "point size," for these are exactly reversed in this case!) There is one unfortunate type face commonly used on such machines, "Script," which is designed to look like handwriting and is intended to be used only in personal correspondence. Some typists mistakenly use "Script" when *italic* lettering is called-for, and the product looks unprofessional. "Light Italic" or "Italic Courier" are better choices. The typical "Script" typeface looks like this:

SCRIPT looks unprofessional: *use LIGHT ITALIC or ITALIC COURIER instead.*

§11. If an author discovers that he or she simply cannot obtain the services of a typist capable of producing good, camera-ready copy, the

Managing Editor is willing to find a typist who can type the manuscript under his supervision, if the author is prepared to pay for such services. Preparation of the plates, however, *must* be done by the author. Those wishing to proceed in this manner should send a draft of their paper to the Managing Editor, who will obtain an estimate of the costs for typing. Such preparation may delay publication of the article to the following issue.

STEP 5. ABOUT OFFPRINTS AND REPRINTS OF YOUR ARTICLE

OFFPRINTS are produced during the press run, and may be ordered by authors from MYCOTAXON at prices indicated on the manuscript acceptance form sent by the Managing Editor. REPRINTS are produced by your local printer at a later time, from the negatives used in original production of the paper (but may also be produced by copying the printed page).

Most authors will want to order either offprints or reprints, and either may be obtained rapidly. Offprints are normally shipped to authors within a few days after publication of an issue. At that time the printer returns the negatives used in printing the issue to the Managing Editor, who proceeds to separate the negatives into individual articles. These negatives are returned to the author, along with special cover copy in case authors wish to have covers made, and along with the original manuscript, normally within three weeks of publication date. The author can then take the negatives (and cover copy, if desired) to a local printer who can produce photo-offset reprints from the negatives supplied. The cost of reprints is usually significantly higher than offprints, since additional presswork is involved, and authors are urged to compare prices of offprints with locally-produced reprints at the time their manuscript acceptance form is returned.

STEP 6. SUBMITTING YOUR MANUSCRIPT

KEEP in mind that your manuscript will be reproduced exactly as it is sent. Cleanliness is an absolute essential. Please review the following procedures and be sure that you have completed them all:

(A) The following are the ten most common reasons why manuscripts are likely to be rejected on technical grounds. Examine your paper to be certain you have not committed these errors:

(1) TITLES of papers are not in CAPITALS, or include one or more underlined or *italicized* words, or author citations are used for taxa (see fourth paragraph ["Title"] on first page of these instructions).

(2) TITLE page is not shorter than other pages, the typist forgetting to leave room for the MYCOTAXON header (see Step 4, §4).

(3) MISCALCULATION of page length or width for authors not using manuscript paper (Step 3), particularly for those using word-processors.

(4) AUTHOR'S name(s) and manuscript page numbers typed on second and succeeding pages without at least 4 blank lines between that and the text (Step 4, §7).

(5) ILLUSTRATIONS and their legends were prepared *after* the manuscript was typed, resulting in large, blank spaces that should have had text matter (Steps 3 and 4).

(6) FAILURE to leave enough blank space for an illustration accompanied by a legend on the same page (Step 3).

(7) LEGEND for a photographic plate typed on the same page with the photographs – these must be on separate sheets with the legend as a part of the text manuscript exactly where it will finally appear (Step 3).

(8) CALCULATION of illustration reduction incorrect – either (i) incorrect amount of space left in typed manuscript, or (ii) legend gives magnification(s) failing to take into account reduction in printing (88% of original for Elite copy, 73% of original for pica copy, for example) (Step 3).

(9) MANUSCRIPT typed with 1-1/2 spacing or double-spacing instead of single-spaced (Step 4, §6).

(10) A blank line was left between references cited (Step 4, §6).

(B) It is necessary to proofread, at least *twice,* the typist's final, single-spaced, camera-ready copy against the manuscript you gave the typist. We urge you to read it aloud, with another person, reading every word slowly, every punctuation mark, every underline, etc. Any errors should then be corrected by your typist. Proofread those corrections, too!

(C) Make a good photocopy of your completed manuscript to keep for your own records and as insurance against loss in the mails.

(D) Prepare your *covering letter,* addressed to the appropriate Co-Editor, which should include the following:

(1) your full name and mailing address
(2) date of mailing
(3) title of your article
(4) total number of manuscript pages (remember that blank pages devoted wholly to illustrations are counted and numbered at the appropriate place in the text where they are to appear)
(5) name(s) and address(es) of pre-submission reviewer(s) to whom you sent the manuscript, *or* copies of their reviews
(6) any instructions on cross-reference pages (Step 4, §7)

(E) Wrap your manuscript and plates carefully. Be sure your name and figure number is marked with a *soft* pencil on the *back* of each mounted plate. Send your covering letter and complete manuscript to the appropriate Co-Editor, preferably by Certified, Insured, or Registered mail.

(F) Within 2 weeks after a Co-Editor has received your manuscript, he will decide whether it is acceptable. In some instances the Co-Editor may decide to contact a pre-submission reviewer before his giving acceptance. If acceptable, he will send it to the Managing Editor, who will either accept it as submitted or reject it on technical grounds, pending correction of those problems. Poorly typed papers will necessarily be rejected, even when the scientific content is worthy of publication. Authors should expect to receive notice of acceptance or rejection of their manuscript within one month of its receipt by a Co-Editor.

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Pg.	190	line 5	for CUP-IN 122 read CUP-IN 22

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Pg.	472	line 16	for 0.5-1.0 mm read 0.5-1.0 μm

ERRATA, VOLUME TWENTY-FIVE

Pg.	550		Replace drawing with that on pg. 552
		lines 6-14	Go to pg. 552 (follow text on pg. 551)
	552		Replace drawing with that on pg. 550

ERRATA, VOLUME TWENTY-SIX

Pg.	187	line 13	for **berberidicolum** read **berberidicola**
	195	1	for **berberidicolum** read **berberidicola**
	242	9	for *pseudonepalense* read *pseudonepalensis*
	358	25	for Svrek read Svrček

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